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

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DEDICATION

For this thesis, I sincerely dedicated to my beloved father, Shafie bin Md Saad, already give unwavering love, unwavering support, and endless sacrifices have shaped me into the person I am today. Thank you for being my pillars of strength and for instilling in me the values of perseverance and resilience. This achievement is a testament to your unwavering belief in me. To my esteemed supervisor, Ts. Dr. Mohd. Farid Bin Ismail, who guidance, wisdom, and patience have been invaluable throughout this project. Your mentorship and insightful feedback have helped me grow both personally and professionally. I am grateful for the opportunity to learn from you and for your unwavering support. I extend my heartfelt gratitude to all those mentioned above. Without your guidance, encouragement, and belief in my abilities, I would not have been able to complete this work. Your contributions have been invaluable, and I am forever grateful for your presence in my life. This dedication is a reflection of my deepest appreciation and recognition for the impact you have had on my journey. Thank you for being the driving force behind my success.

ABSTRACT

Aquaculture is largely used to feed the globe, especially fish. Water quality issues plague tilapia aquaculture. Tilapia farms need IoT water quality monitoring. This gadget improves yield by monitoring water conditions in real time. IoT helps farmers enhance efficiency, meet market demands, and sustainably produce fish. This project will boost tilapia production using an IoT-based water quality monitoring system. Studying IoT devices, water characteristics, cost-effectiveness, and environmental impact. IoT-based monitoring may help tilapia farms grow sustainably and meet protein needs. By addressing water quality challenges caused by pollution, low oxygen levels, and environmental changes like temperature and water availability, effective treatment, waste management, and monitoring systems may make tilapia aquaculture more sustainable and consistent. Tilapia farming at Alai, Melaka is the key experiment in this study. A comprehensive approach is needed to reverse tilapia productivity. Assessing the pond's water quality regularly helps find and fix problems. A monitoring system may enhance tilapia aquaculture output and sustainability. Next, secondary studies examining existing data underline the need of monitoring water quality factors including temperature, dissolved oxygen, and pH to optimise tilapia development. The water quality parameters for temperature, DO, and pH of the tilapia farming monitoring system are 20–35 °C, 3.2–4.7 mg/L (morning), 5.4–6.4 mg/L (afternoon), and 6.5–8.3 respectively. The proposed method involves the installation of sensors through a monitoring device, together with the establishment of an experiment which guarantees controlled conditions for the purpose of data collecting that is correct. For the purposes of connection with the Blynk application, a microcontroller (Arduino Uno) and an ESP8266 module are used for the purposes of data collecting, processing, and transmission. an accurate into temperature changes, pH inconsistencies, and dissolved oxygen levels are revealed by the results and analysis, which highlights the significance of sensor calibration. The results from this study of this research highlight the necessity of carrying out water quality monitoring in order to successfully cultivate tilapia. Both the technique and the monitoring system that have been developed have the objective of providing important data that can be used to optimize conditions, increase production, and ensure the sustainability of tilapia farming. However, the findings highlight the need of spending additional attention to sensor calibration in order to get accurate and dependable results in the implementation of efficient tilapia farming procedures. Overall, dependability, and expansibility demand better analytics and machine learning. IoT-based water quality monitoring might improve tilapia aquaculture, productivity, and sustainability.

ABSTRAK

Akuakultur sebahagian besarnya digunakan untuk memberi makan dunia, terutamanya ikan. Masalah kualiti air melanda akuakultur tilapia. Ladang Tilapia memerlukan pemantauan kualiti air IoT. Alat ini meningkatkan hasil dengan memantau keadaan air dalam masa nyata. IoT membantu petani meningkatkan kecekapan, memenuhi permintaan pasaran, dan menghasilkan ikan secara lestari. Projek ini akan meningkatkan pengeluaran tilapia menggunakan sistem pemantauan kualiti air berasaskan IoT. Mengkaji peranti IoT, ciri air, keberkesanan kos, dan kesan persekitaran. Pemantauan berasaskan IoT boleh membantu ladang tilapia berkembang secara mampan dan memenuhi keperluan protein. Dengan menangani cabaran kualiti air yang disebabkan oleh pencemaran, tahap oksigen yang rendah, dan perubahan alam sekitar seperti suhu dan ketersediaan air, rawatan yang berkesan, pengurusan sisa, dan sistem pemantauan boleh menjadikan akuakultur tilapia lebih mampan dan konsisten. Penternakan Tilapia di Alai, Melaka adalah percubaan utama dalam kajian ini. Pendekatan komprehensif diperlukan untuk membalikkan produktiviti tilapia. Menilai kualiti air kolam secara berkala membantu mencari dan menyelesaikan masalah. Sistem pemantauan boleh meningkatkan pengeluaran akuakultur tilapia dan kelestarian. Seterusnya, kajian sekunder yang mengkaji data sedia ada menggariskan keperluan pemantauan faktor kualiti air termasuk suhu, oksigen terlarut, dan pH untuk mengoptimumkan pembangunan tilapia. Parameter kualiti air untuk suhu, DO, dan pH sistem pemantauan pertanian tilapia adalah 20-35 ◦C, 3.2–4.7 mg/l (pagi), 5.4–6.4 mg/L (tengah hari), dan 6.5–8.3 masing-masing. Kaedah yang dicadangkan melibatkan pemasangan sensor melalui peranti pemantauan, bersama-sama dengan penubuhan eksperimen yang menjamin keadaan terkawal untuk tujuan pengumpulan data yang betul. Untuk tujuan sambungan dengan aplikasi Blynk, mikrokontroler (Arduino Uno) dan modul ESP8266 digunakan untuk tujuan pengumpulan, pemprosesan, dan penghantaran data. Tepat mengenai perubahan suhu, ketidakkonsistenan pH, dan tahap oksigen terlarut didedahkan oleh hasil dan analisis, yang menekankan kepentingan kelibrasi sensor. Hasil daripada kajian penyelidikan ini memastikann keperluan untuk menjalankan pemantauan kualiti air untuk berjaya ternakan tilapia. Teknik dan sistem pemantauan yang telah dibangunkan mempunyai objektif untuk menyediakan data penting yang boleh digunakan untuk mengoptimumkan keadaan, meningkatkan pengeluaran, dan memastikan memajukan penternakan tilapia. Walau bagaimanapun, kajian ini menekankan keperluan untuk memberi perhatian tambahan kepada kelibrasi sensor untuk mendapatkan hasil yang tepat dan boleh dipercayai dalam pelaksanaan prosedur ternakan tilapia yang cekap. Secara keseluruhan, kebolehpercayaan, dan kebolehluasan memerlukan analisis dan pembelajaran alat pemantauan yang lebih baik. Pemantauan kualiti air berasaskan IoT mungkin meningkatkan akuakultur tilapia, produktiviti, dan kelestarian.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	-	Alternating Current
BEST TILAPIA	-	Bogor Enhanced Strain of Tilapia
CPU	-	Central Processing Unit
DC	-	Direct Current
DO	-	Dissolve Oxygen
DOF	-	Department of Fisheries Malaysia
GIFT TILAPIA	-	Genetic Improvement of Farmed Tilapia
GSM	-	Global System For Mobile
IC	-	Integrated Circuit
IoT	-	Internet of Thing
MTP	-	Media Transfer Protocol
NH_3	-	Ammonia
NIFI TILAPIA	-	National Inland Fisheries Insitution of Tilapia
NO_2	-	Nitrite
NO_3	-	Nitrate
PH	-	Potential Hydrogen
SD	-	Secure Digital

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CHAPTER 1

INTRODUCTION

1.1 Background

As the world's population continues to grow at an unprecedented rate. According to data from the United Nations,(United Nations Population Fund, 2023) the global population has more than tripled since the mid-twentieth century, reaching 8.0 billion in mid-November 2022 from an estimated 2.5 billion in 1950. This increase of 1 billion people since 2010 and 2 billion since 1998 highlights the rapid growth. Projections suggest that the world's population will further rise by nearly 2 billion individuals in the next 30 years, reaching 9.7 billion by 2050, and potentially peaking at approximately 10.4 billion in the mid-2080s. Consequently, the expanding population will inevitably drive the demand for an increased food supply, as humans require sufficient nourishment to sustain their lives and carry out daily activities. Access to healthy and nutritious food in appropriate quantities, as recommended by the food pyramid, becomes essential to meet the nutritional needs of a larger global population.

Protein sources, such as fish, play an important role in the food pyramid. Fish can be obtained from both the sea and rivers through fishing activities. Many communities rely on fishing to supply their protein needs, with fishermen catching various fish species to provide sustenance. Additionally, aquaculture, or fish farming, is another method of obtaining fish as a protein source. Through controlled environments, fish are raised in freshwater or marine facilities, ensuring a steady supply of fish for consumption. Whether obtained through fishing or aquaculture, fish provides a valuable protein source that contributes to a balanced and nutritious diet.

Aquaculture plays a vital role in providing a sustainable protein source, particularly in Malaysia where tilapia farming is prevalent. However, there is a significant disparity between the low production of tilapia fish and the high demand for it. Tilapia farming has gained popularity due to its adaptability and high growth rate, making it a favorable choice for aquaculture. Despite the efforts to meet the increasing demand, the production of tilapia fish falls short. This disparity highlights the need for further advancements and investments in tilapia farming techniques to bridge the gap between supply and demand, ensuring a steady and sufficient protein source for the population in Malaysia.

One of the main challenges in tilapia farming relates to environmental factors, particularly water quality. The quality of water directly affects the production of tilapia, and inadequate water conditions can hinder the ability to meet market demands. To address this issue, the implementation of Internet of Things (IoT) devices for monitoring water quality becomes crucial. These IoT devices enable continuous monitoring of water parameters, allowing farmers to assess the condition of the water in real-time rather than relying on periodic checks. By utilizing IoT technology, tilapia farmers can improve water quality management, promptly detect any deviations or issues, and take necessary actions to optimize conditions for tilapia production. This innovative approach not only helps to enhance production efficiency but also ensures that the demand for tilapia in the market can be met consistently.

1.2 Problem Statement

The development of an IoT-based monitoring system for water quality in tilapia farming aims to address the pressing issue of maintaining optimal water conditions for sustainable tilapia production. The current challenges in tilapia farming, including environmental factors, climate variations, and water quality fluctuations, have a significant impact on production efficiency and the ability to meet market demands. The lack of real-time and continuous monitoring methods often leads to suboptimal water conditions, affecting the health and growth of tilapia. Therefore, the implementation of an IoT-based monitoring system becomes essential to provide farmers with accurate and timely information on crucial water quality parameters such as potential hydrogen (pH), temperature, dissolved oxygen (DO), and turbidity. This system will enable proactive decision-making, precise control of water conditions, and effective management strategies, ultimately enhancing the overall productivity and sustainability of tilapia farming operations. On tilapia farms, water quality depends on an environment suited to growth. Maintaining the proper equilibrium between nutrient input and the assimilative capacity of the water can produce such an environment. However, the greater the number of fish grown, the greater the demand for fish production, and the greater the number of additional factors required to attain excellent water quality (Bonnie Waycott, 2015).

1.3 Research Objective

The main aim of this research is to estimate system wide Development of an IoT-Based Monitoring System for Water Quality in Tilapia Farming. Specifically, the objectives are as follows:

a) To develop of an IoT-Based Monitoring System for Water Quality in Tilapia Farming.

b) To ensure the monitoring device for water quality solution applying an IoT-based monitoring system was be function properly and produce a accuracy or percise value to farmers.

1.4 Scope of Research

The scope of this research are as follows:

1) The research was restricted to the Tilapia Fish farm raised in Alai, Melaka.
2) The IoT device will be developed based on the criteria provided to monitor and collect relevant environmental data. The gadget will feature sensors, wireless communication modules, and a microprocessor to collect, process, and transfer the data.
3) The accuracy, reliability, and efficacy of the IoT device in monitoring environmental elements that affect Tilapia fish production will be evaluated.
4) Analysis of current fish production techniques as well as water parameters such as DO, pH, temperature, and alkalinity that affect fish development and survival. This information would be used in this study to develop an innovative technique for improving the water quality conditions in the fish pond, hence increasing fish productivity.
5) The study would also look at the new procedure's cost-effectiveness and the potential financial rewards from employing it. It will also evaluate any connected sustainability concerns as well as the new procedure's possible environmental impact.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Currently, numerous studies are being conducted to assess water quality for fish farming and develop monitoring systems that enable effective control of water conditions. Furthermore, enhancing these monitoring systems through the utilization of the IoT is significant to fish farmers. This study places particular emphasis on red tilapia, a commonly cultivated fish species. This part should be explained more about tilapia farming, parameters of water quality, and monitoring systems. This subtopic is more important because it helps to know the parameters of water quality for tilapia farming and the equipment in the monitoring system.

2.2 Tilapia farming

Tilapia is a freshwater fish species that is popular in Malaysia. This fish originates from Africa and has been introduced to many countries around the world, including Malaysia. There are five common tilapia species that are raised in Malaysia, including Taiwan Red Tilapia, National Inland Fisheries Insitution of Tilapia (NIFI Tilapia), Chitralada Tilapia, Bogor Enhanced Strain of Tilapia (BEST Tilapia), and Genetic Improvement of Farmed Tilapia (GIFT Tilapia) (Mohd Khairul, 2023). Before carrying out this research, it is essential to have an understanding of the statistical data, as well as the challenges and concerns surrounding fish farming today.

2.2.1 Statistical Data

In Malaysia, aquaculture plays a significant role in the generation of various fish products, including Catfish, Black Tilapia, and Red Tilapia. This study focuses on controlling the production of red tilapia in the industry. The demand for Tilapia fish in Malaysia is high, but limited production due to several factors can have a significant impact. The Figure 2.1 provides evidence of the production results of Tilapia fish in Malaysia from 2018 until 2021 based on the data from the annual fisheries statistics volume in the Department of Fisheries Malaysia (DOF).

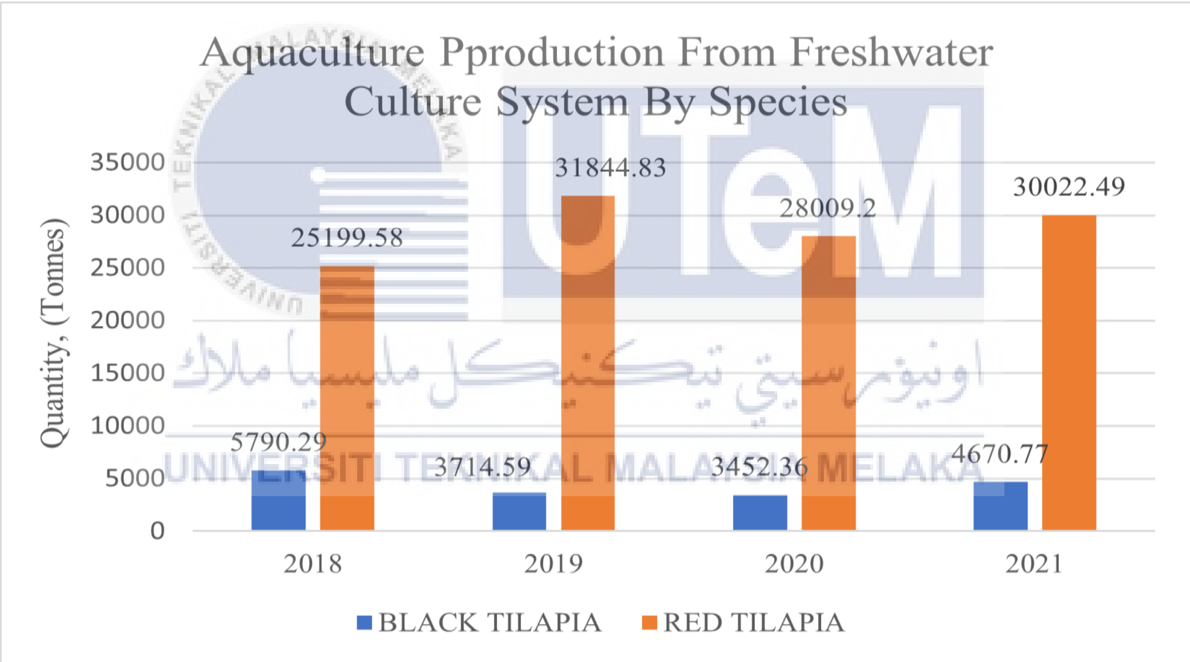


Figure 2.1 The graph of Aquaculture Production From Freshwater Culture System By Species.

2.2.2 Problem and Current Issues

Optimal water quality is critical in tilapia farming for effective output and satisfying market expectations. It is because Tilapia is very sensitive to environmental circumstances, water quality has a direct influence on their development, health, and general well-being. Inadequate water quality may cause a variety of problems, including decreased growth rates, increased disease susceptibility, and low feed conversion efficiency. Temperature, dissolved oxygen levels, pH balance, ammonia, nitrite, and nitrate concentrations, as well as the presence of contaminants or toxins, are all important factors to monitor and regulate. The problem in Tilapia farming was considered by (Abd El-Hack et al., 2022), in their research, they list and analyze many of these factors, such as stocking densities, different feeding schedules and rates, parameter of water quality is temperature, DO, pH, ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3) concentration, feeding schedules, feed cost, and Tilapia tank-culturing system. These things can have a big effect on Tilapia's body weight, makeup, ability to live, behavior, food intake, food conversion ratio, eating efficiency, health, and ability to reproduce.

According the AnnJil Chong (2023), this interview focuses on the struggles of the aquaculture industry in Malaysia and how they have caused a rapid decrease in production. The type of the challenges and issues of aquaculture industry in Malaysia is cost elasticity, environmental pollution, environmental change, labor shortages and land acquisition cost. In fact, pollution and other changes in the surroundings can have a big effect on the water quality in tilapia farms. Most tilapia farms get their supply of water from the natural sources of water. So, the surrounding world has a direct effect on the quality of the water that comes in. Pollutants can get into the water system through environmental pollution, such as farming runoff, industry release, and bad waste management.

Some of these toxins are heavy metals, herbicides, fertilizers, organic matter, and different chemicals, all of which can hurt the quality of the water and, in turn, the growth and health of tilapia. Changes in the environment, like climate change, pollution, and development, can also affect the quality of water in subtle ways. Changes in how it rains, how hot or cold it gets, and how the land is used can all lead to changes in how much water is available, how hot or cold it is, how much nutrients are in it, and how fast it flows. All of these things can affect the quality of the water in tilapia farming systems.

2.3 Parameter of Water Quality

Water quality refers to the physical, chemical, and biological characteristics of water that determine its suitability for various purposes, including aquaculture. In the context of tilapia farming, several parameters are commonly used to assess and monitor water quality such as temperature, DO and pH. Regular monitoring and management of these water quality parameters are essential in tilapia farming to ensure optimal conditions for growth, health, and overall productivity. This involves regular water testing, implementing appropriate treatment systems and adopting sustainable practices to minimize pollution and maintain favorable water quality conditions.

2.3.1 Temperature

Monitoring the temperature of the water is essential for fish farmers since temperature has a direct impact on the behaviour, eating, and reproduction of fish. Changes in temperature that are too high or too low from the ideal range might cause fish to die or develop abnormally. Therefore, keeping water temperatures at appropriate levels is very necessary for optimal fish culture (Steve A. Obado, 2019).

Temperatures between 20 and 35 °C are ideal for tilapia development. If the temperature drops below 20 °C, growth slows dramatically, and death occurs at 10 °C. Fish tank temperatures may be impacted by both the ambient environment and the water supply (Megat & Sairul, 2021).

Tilapias are fish with a cold-blooded metabolism. They are sensitive to shock when there is a fast change in the water temperature because they are unable to maintain a consistent temperature in their bodies. This survey is not maintained in the pond. The temperature should have been kept between 25 and 32 °C at all times. Because of this, the tilapia in the pond is impacted as a result of these variables (Wongmeekaew et al., 2019).

2.3.2 Dissolved Oxygen (DO)

In tilapia farming, one of the most important variables to take into consideration is the dissolved oxygen level. Tilapias are warm-water fish and require adequate oxygen levels in the water for their survival, growth, and overall health. Dissolved oxygen refers to the amount of oxygen gas dissolved in water and available for aquatic organisms to breathe. The DO in the water is what keeps the aquatic ecosystem's entire metabolic process running smoothly (Lee & Wang, 2020; Rennel & Molato, 2022).

The optimal values of dissolved oxygen for fish production are between 5.0 and 9.0 in freshwater and 6.5 and 9.0 in marine environments, respectively (Harun et al., 2018). The measurement of DO ranges from 3.2 to 4.7 mg/L in the morning and from 5.4 to 6.4 mg/L in the afternoon, with the lowest value occurring in the morning and afternoon for ponds consisting of ex-mining land soil and topsoil (Hidayati et al., 2019).

The presence of oxygen in the water's dissolved state is essential for the survival of fish. When performing at a high level of accuracy and speed, the oxygen content should not drop below 3.0 mg/liter in order to prevent harm (Wongmeekaew et al., 2019).

2.3.3 Potential Hydrogen (pH)

Tilapia production should take pH into account because of the direct impact it has on the fish's health, growth, and general performance. The acidity or alkalinity of water is measured on the pH scale, which runs from 0 to 14, with 7 representing neutrality. The growth and survival of farmed tilapia depend on keeping the water's pH within a narrow range (Hasani et al., 2021).

Tilapias are quite sensitive to changes in water pH. Too much acidity or alkalinity in the water can put fish under unnecessary stress, slowing their development and making them more exposed to sickness and infection. Keeping the pH level within a fish-friendly range is essential. Adjust the pH to a value between 6.5 and 8.5. (Othman et al., 2020).

Water in fish ponds has a pH that varies throughout the day and night, typically decreasing the range anywhere between 6.5 and 8.3.(Wongmeekaew et al., 2019).

2.3.4 Summary for Parameter of Water Quality

The data from the research is presented in Table 2.1 his data presents the value of the type of parameter for water quality to Tilapia fish and helps to monitor the system.

Table 2.1: The value of parameter for water quality.

Author	Temperature (^{0}C)	DO (mg/L)	pH
Megat & Sairul,2021	20 – 35	-	-
Wongmeekaew et al.,2019	25 - 32	not drop below 3.0	6.5 – 8.3
Harun et al.,2018	-	5.0 – 9.0	-
Hidayati et al.,2019	-	3.2 - 4.7 (morning) and 5.4 - 6.4 (afternoon)	-
Othman et al.,2020	-	-	6.5 – 8.5

2.4 Water quality Monitoring System

The environmental circumstances and the way that water is used both influence the chemical composition of water. Maintaining a healthy pond should focus on controlling this composition of a healthy pond should focus on controlling this composition to get the greatest possible outcomes. It is necessary for aquaculture operations to understand both the physical and chemical factors that contribute to either high or low water quality (Steve A. Obado, 2019).

2.4.1 Type of Sensor

There are several types of sensors that can be used in tilapia farming to monitor various parameters and ensure optimal conditions for the fish. Here is the type of used sensors in tilapia farming in this task such as Temperature Sensors, Dissolved Oxygen Sensor and Potential Hydrogen Sensor.

Since tilapia are temperature sensitive, water temperature sensors are essential. These water-based sensors continually detect and report temperature. Digital Temperature Sensor (Dallas) DS18B20 temperature sensors include stainless-steel tips. It accurately measures temperatures from -55 to 125 °C (Harun et al., 2018). One-wire waterproof temperature sensor DS18B20. It communicates by one-wire and measures temperatures from -55°C to +125°C with ±5°C precision. 9-12bit output resolution, 750ms 12 bit conversion time. (Alchalaby et al., 2019; Nanyanzi et al., 2021). The DS18B20 temperature sensor was used. Due to its cheap cost, 1-wire protocol compatibility, and high accuracy from −55 °C to 125 °C, this sensor is popular. The 1-wire serial protocol lets you connect numerous sensors to a single data line. The master device initiates and manages communication with one or more slave devices (Koritsoglou et al., 2020). The DO Sensor must be use to know the value of oxygen concentraion in the water. According the Harun et al. (2018), The Atlas Scientific

DO sensor used here is founded on dissolved oxygen expressed in weight of oxygen over volume of water (mg/L) or its equivalent, parts per million (ppm). It can measure a wide range of oxygen 0-35 mg/L.

Next, For the purposes of this study, the pH Sensor will be used to acquire the water's pH value. Therefore, research was conducted on several of the pH sensors to confirm that this sensor is able to provide correct results in this system. According (Sajal Saha et al., 2018), an Analog pH Sensor for Arduino (SEN0161) manufactured by Dfrobot is utilized to determine the pH level of the water. This pH sensor was designed specifically for Arduino and includes built-in functions and connections for your convenience. This sensor has a range of 0-14 pH. At a standard temperature of 25 ºC, it is accurate to within 0.1 pH, and it can be used in temperatures from 0 to 60 ºC. Only a small part of the sensor needs to be put into the water. This pH monitor is reliable for a half year when the water is clear and for one month when the water is dirty. Next, the analog pH Meter Kit SKU such as SEN0169 pH sensor used in this instance is capable of measuring the whole range of acidity to alkalinity. For months, it can operate continuously in turbid, very acidic, and alkaline solutions (Harun et al., 2018).

2.4.2 Microcontroller

A microcontroller is a compact computer built into a single integrated circuit (IC) and intended for use in embedded systems. It has an integrated Central Processing Unit (CPU) chip with memory, input or output peripherals, and a processor core. Robotics, consumer electronics, automotive systems, and industrial automation are just a few of the many fields where microcontrollers are often employed. Based on the research, the microcontroller such as Arduino version is Arduino UNO used to monitoring system (Sajal Saha et al., 2018). A microcontroller board called Arduino Uno is based on the

ATmega328P. It features 14 digital input/output pins and 6 analog input pins. Its suggested input voltage range is 7–12 volts, while its working voltage is 5 volts.

Next, Arduino Uno was mainly used as the microcontroller of the device (Rennel & Molato, 2022). The device is equipped with three sensors such as pH sensor, DO sensor and temperature sensor. The model to be used, the researchers built a water quality monitoring device consist of integrated array of sensors and Arduino microcontroller. The sensors are selected based on their availability in the local market and compatibility with the Arduino microcontroller (La Madrid et al., 2019). According the Banjao et al. (2020), it needs to initialize the system where a Microcontroller and the sensors are and the ESP32 establishes a connection to the internet. Then the Microcontroller will collect the data readings obtained from the sensors that are placed in the water tank.

2.4.3 Internet of Things embadded

The IoT refers to a network of physical devices, vehicles, appliances, and other objects embedded with sensors, software, and connectivity capabilities to interchange data and communicate via the Internet. These devices, commonly known as "smart" devices, can collect, transmit, and receive data, allowing them to perform a variety of actions and tasks. According (Sajal Saha et al., 2018), Any android smartphone with Media Transfer Protocol (MTP) can be used in this purpose. MTP permits media files to be exchanged atomically to and from portable devices. Next, the system makes use of a companion application written in Visual Basic and a microchip that allows for comparative assessment and remote monitoring of water quality using a Global System for Mobile (GSM) module (La Madrid et al., 2019). A vbscript-written msSQL script retrieves the data from the sensors using the GSM module, which is used for data collecting. In future generations of the gadget, a solar power and Secure Digital (SD) card module may be added to the setup.

Then, ThingSpeak is a platform for the Internet of Things (IoT) and one of the tools for data aggregation. To display data entering the cloud in real-time, data from a variety of sensors is provided over the Hypertext Transfer Protocol (HTTP) protocol through the internet using this cloud. While the platform has APIs for data collection, it will continue to update the data reading from the aquaponic system. By employing an ESP32 Wi-Fi module to broadcast and receive data in real-time into the cloud, ThingSpeak was developed to link it to the Arduino (Banjao et al., 2020).

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology to develop a monitoring system of water quality for tilapia farming provides the framework for the research and defines the strategy to achieve the objectives of the study. The research will focus on tilapia farming in areas where water quality is a problem. This study gives a brief overview of the significance of water quality monitoring in ensuring the health and production of tilapia, with a primary emphasis on the development of a monitoring system for water quality in tilapia farming. In addition, this highlights the need to develop a system that is based on the IoT, which allows continuous and real-time monitoring of the factors that determine water quality. It is possible for such a system to provide remote monitoring capabilities, instantaneous anomaly identification, and proactive control of water quality by using the IoT technology. This would overcome the limits of existing monitoring techniques that are used in tilapia farming.

3.2 Workflow

A workflow method, as shown in Figure 3.1, is necessary to provide ordered and systematic results. To design the monitoring system, all available information, expertise, and services should be used to the fullest extent feasible. For instance, the data may be collected from technical documents and research publications that have been designated as guidelines for the product parameter. Once the previous stage of work in the creation of a product is successful, the subsequent step of work begins. The procedure starts with a thorough and exact schedule that is based on research and an effective flowchart for project development.

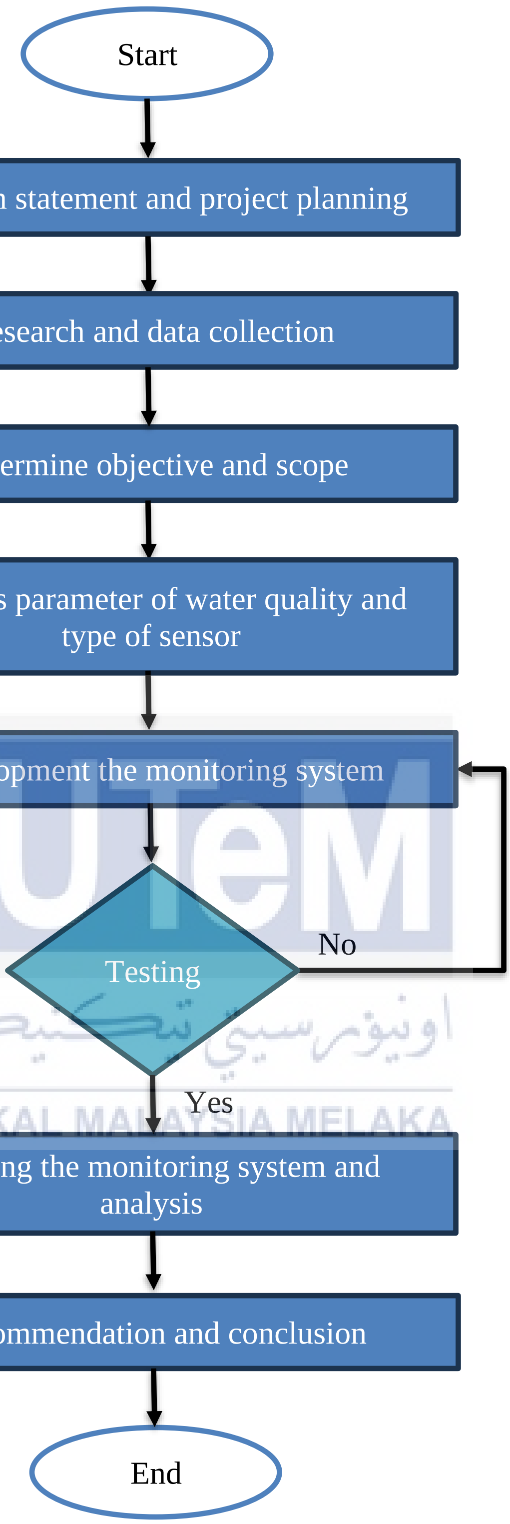


Figure 3.1: The flowchart of develop the monitoring system

3.3 Experiment Study

In a primary experimental study focusing on tilapia fish, a number of problems and concerns pertaining to their health and growth may emerge. Temperature, (DO), and pH are only a few of the water quality variables that can have an effect on these issues. Then, in a secondary experimental study is appropriate parameter ranges for these factors are essential for ensuring optimal tilapia conditions. The influence of temperature on metabolic rates, growth, and reproduction is significant. DO is required for fish respiration in order to maintain healthy populations of tilapia. pH is another important variable that influences the physiology and behaviour of fish. Maintaining these optimal ranges for temperature, DO, and pH is necessary for mitigating potential problems and promoting the health and productivity of tilapia in aquaculture systems.

3.3.1 Primary Study

Based on the information from farmer when first site visit. The compromised water quality is one of the potential factors contributing to the decrease in tilapia production in Tilapia farmer. If the water in the aquaculture area is contaminated or deficient in oxygen, the health and growth of the tilapia may be negatively affected. Pollution from agricultural effluent or improper waste management practices can introduce hazardous substances into the water, negatively influencing fish populations. Excessive organic matter can deplete oxygen levels, causing tension and stunted growth. Water quality parameters such as DO, pH, and temperature must be tested and monitored routinely. Implementing appropriate water treatment methods and enhancing waste management practices can aid in maintaining tilapia-friendly water quality.

External environmental factors can also play a role in tilapia production. Fluctuations in temperature, extreme weather events, or changes in water availability can impact the fish's growth and reproductive capabilities. Tilapia prefers warm water, and sudden drops or rises in temperature can cause stress and affect their metabolism and growth. Changes in water availability, such as droughts or excessive rainfall, can disrupt the farming system. Managing these environmental factors by implementing appropriate infrastructure, such as temperature control mechanisms and water management systems, is important to ensure optimal conditions for tilapia growth.

In summary, addressing the reduction in tilapia production in farmer’s pond requires a comprehensive approach. Regular assessments of water quality will help identify and address any issues in these areas. Meanwhile, implementing appropriate measures, such as providing a monitoring system, can improve tilapia farming productivity and ensure sustainable production in Tilapia farming.

3.3.2 Secondary Study

A secondary study is a type of research that involves analysing and synthesising present data, information, and findings from previously conducted primary studies. In contrast to primary research, which entails collecting new data directly from original sources, secondary research entails collecting and analysing data that has already been collected by others. The objective of a second study is to summarise, interpret, and integrate existing knowledge and findings in order to generate new insights, validate or challenge existing theories, or provide a broader perspective on a particular problem or water quality parameter in order to develop a monitoring system.

The literature study found that the parameters of water quality for tilapia fish contain data that can be utilised to perform the monitoring system. This data can be used to monitor the water quality. The preferred temperature range for optimum tilapia growth is 20 °C to 35 °C. Growth reduces significantly at temperature below 20 °C and death will occur below 10 °C. The temperature of the fish tank may be affected by the surrounding temperature or the water source used. So, the temperature behaviour is needed to monitor from time to time by temperature sensor (Megat & Sairul, 2021). Next, Oxygen is one of the most essential limiting factors, so if its availability in water is not sufficient to meet the requirements of cultivation biota, all biota activities will be hampered. Morning measurements of DO range from 3.2 to 4.7 mg/L, while afternoon measurements range from 5.4 to 6.4 mg/L. Rice plants and phytoplankton use oxygen at night for respiration, resulting in a reduction of dissolved oxygen in the morning (Hidayati et al., 2019). The pH of water in fish ponds fluctuates throughout the day due to the metabolic activities of aquatic organisms as well as variations in carbon dioxide and oxygen levels. These fluctuations fall within the generally acknowledged range of 6.5 to 8.3, providing a pH environment conducive to the health and survival of fish species (Wongmeekaew et al., 2019). Table 3.1 the values of parameter will consider to setup in monitoring system for Tilapia farming.

Table 3.1: The values of parameter considered in monitoring system.

Parameter of water quality	**Conditions**
Temperature	20 – 35 °C
DO	3.2 to 4.7 mg/L (morning), 5.4 to 6.4 mg/L (afternoon)
pH	6.5 – 8.3

3.4 Proposed Methodology

The Proposed Methodology is an essential element of any research study, project, or investigation, as it provides a clear and systematic strategy for accomplishing the desired results. It consists of the research design, data collection methods, sample selection, data analysis procedures, ethical considerations, resource allocation, schedule, and limitations. It acts as a road map, directing researchers through the necessary steps to effectively address research objectives. So, the methodology for the development of the monitoring system for water quality includes sensor deployment, data acquisition, visualization, and validation methods.

3.4.1 Equipments

Selecting the proper sensor is essential for accurately monitoring and obtaining dependable values for water quality parameters. Temperature, dissolved oxygen, and pH are among the parameters that can be detected by various sensors. Researchers or operators can ensure that the measurements are accurate, consistent, and representative of the actual water conditions by selecting the appropriate sensor for each parameter. This information is essential for monitoring and sustaining the water quality in a variety of applications, including aquaculture, environmental monitoring, and water treatment. Meanwhile, meanwhile, the monitoring device has a few other equipment more important to make sure it will operation and used for monitor water quality in the pond.

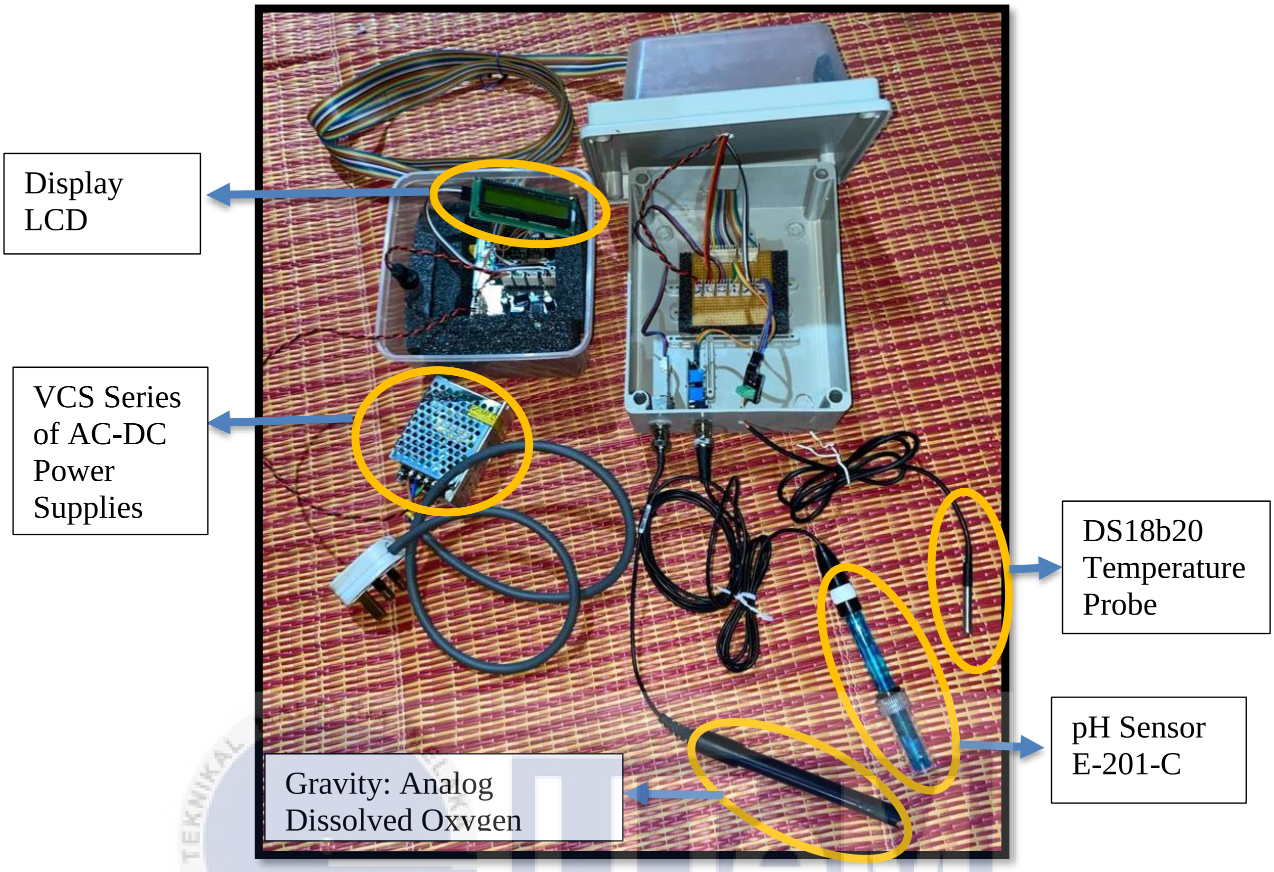
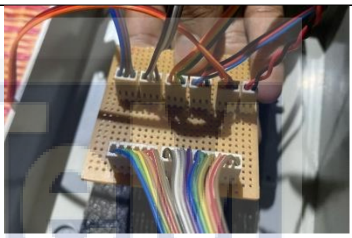


Figure 3.2: Type of equipment at monitoring device.

Figure 3.2 illustrates the three different kinds of sensors, display LCD, and AC-DC power supplies that were utilized in this device. The DS18B20 Temperature Probe Sensor was a component of equipment that was used to measure the temperature of the water, the pH Sensor model E-201-C was used in this device to measure the alkalinity of the water, and the Analog Dissolved Oxygen Sensor from the Gravity model was utilized in this device to measure the amount of oxygen that had been detected in the water at the Tilapia Pond. Next, the LCD screen on this device is used to visually provide the temperature, dissolved oxygen (DO), and pH values to the user. This allows the user to see the data and take appropriate measures to regulate the water quality in the Tilapia Pond. The power supply derived from Alternating Current (AC) must be converted to Direct Current (DC) in order to ensure the functioning of the device.

Table 3.2: The other of component be used for the monitoring device.

Name of component	**Components**
LM2596 DC - DC 3A Adjustable Step-Down (Buck) Converter	
Jumper Wires	
Extension Board	
3-Pin Plug	
Pvc Enclosure Electrical Junction Box	

In the process of setting up this device, various additional components play a crucial role by facilitating the completion of the circuit, ensuring that the device can operate seamlessly. These components are integral for the device's functionality, serving as essential elements to establish a stable and efficient electrical connection. Examples of such components may show in Table 3.2, each contributing to specific functions within the circuit.

3.4.2 Experiment Setup

In designing the experimental setup, careful consideration was devoted to creating a controlled and replicable environment that would enable precise investigation and analysis of the variables under observation. Creating a monitoring device for water quality involves both electronic and mechanical setups to ensure the device functions effectively. When these electrical and mechanical configurations are combined, the water quality monitoring device transforms into a full solution that is able to properly measure and transfer data for the purpose of conducting efficient water quality analysis. It is also important to consider doing routine maintenance and calibration on the equipment in order to guarantee its accuracy and dependability over the long run.

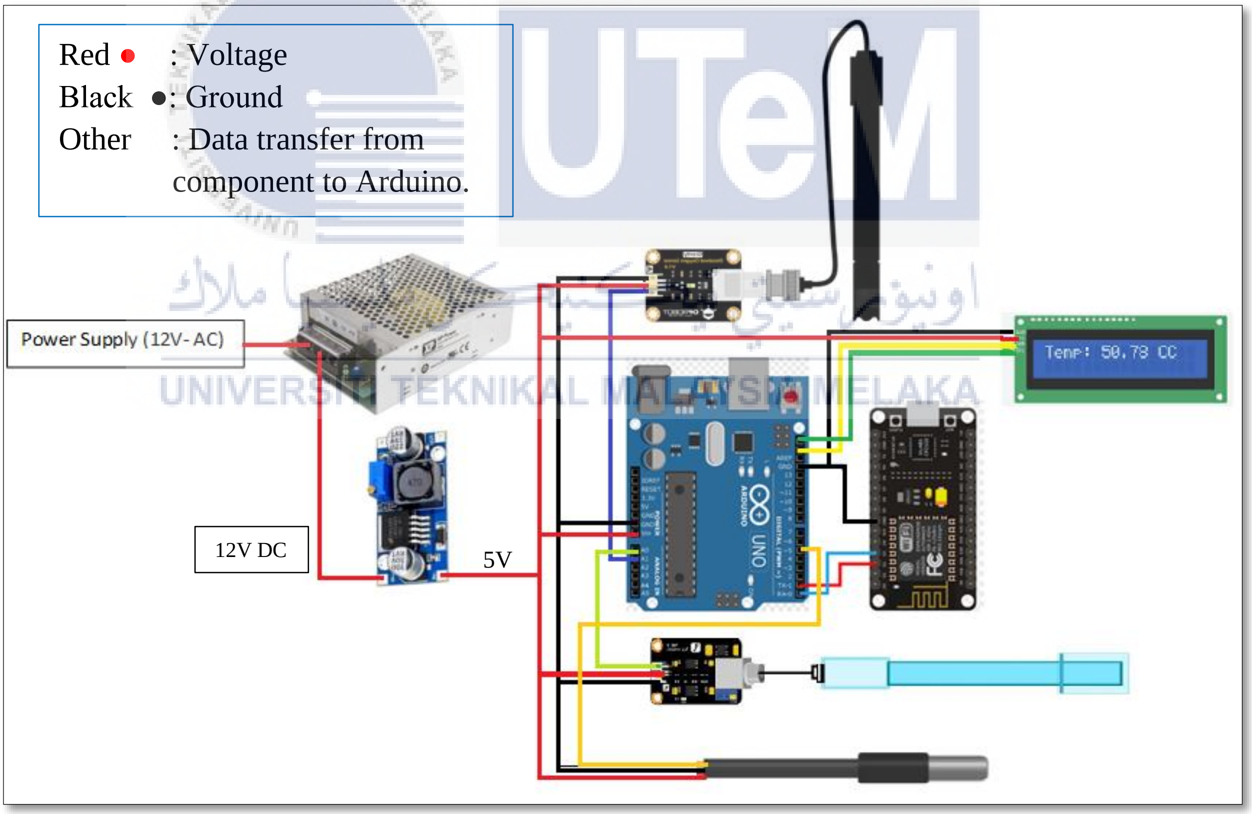


Figure 3.3: Main electronic component setup in monitoring device.

Based on the Figure 3.2 shows a few main electronic was connected to microcontroller. Within the electronic configuration, an array of water quality sensors is used to measure factors such as pH, temperature, and dissolved oxygen (DO). These sensors are the main method used to evaluate various elements of water quality. The analog signals obtained from these sensors are then analyzed by a microcontroller or processor, such as Arduino Uno, using a data collection system that may include Analog-to-Digital Converters (ADCs). The microcontroller is designed to oversee the operation of the sensors, analyze the collected data, and enable connection via Wi-Fi modules. In addition, a dependable power supply system is included, customized to meet the energy needs. This system offers several possibilities, including converting the power from 12-volt AC to 12-volt DC and then reducing the voltage to 5 volts, ensuring that all device components get the appropriate voltage.

Figure 3.4: Mechanical setup for monitoring device.

Based on the Figure 3.4, mechanical setup for monitoring device was used sturdy and waterproof enclosure is designed to safeguard the electronic elements from environmental factors like water, dust, and temperature variations, ensuring the device's durability. All the sensor was sinking in the Tilapia Pond for detect the value measured. Then, the casing applied as coatings and materials to protect sensors from fouling or corrosion, especially the device will be deployed in water bodies with varying conditions.

3.4.3 Data Acquisition, Analysis and Transmission

The water quality monitoring equipment relies on its data collecting, transmission, and analysis components to provide reliable and accurate data. The data collection system is the backbone of the system; it communicates with several sensors that measure water quality to record important parameters such as temperature, dissolved oxygen, and pH. In order to convert the analogue signals received from the sensors into digital data, a microcontroller, which may be equipped with Analog-to-Digital Converters (ADCs), is used.

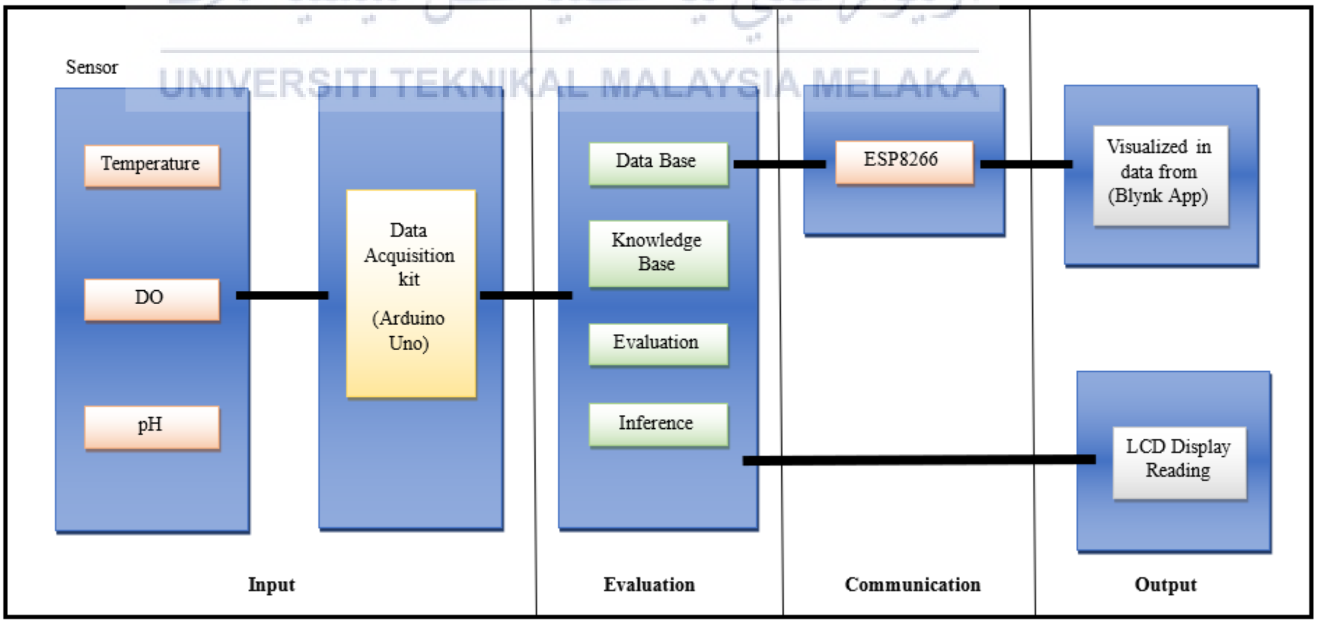


Figure 3.5: The diagram of process for the monitoring device.

Figure 3.5 shows the process from input until the output. The water quality monitoring procedure begins when the sensors detect the sample and transmit voltage values to the Arduino Uno via Analog-to-Digital Converters (ADCs). The Arduino Uno performs a programmed evaluation by using the embedded code for analysis. The calibration procedure is intrinsically included into the programming code executed on the Arduino, guaranteeing that the gathered data is precise and conforms to predetermined requirements. Afterwards, the examined data smoothly transitions to the ESP8266 module for transmission. This module enables communication and operates as the intermediary between the Arduino Uno and the Blynk application. The ESP8266 is programmed to send the assessed water quality data to the Blynk app, which serves as a user-friendly interface for presenting the information. Simultaneously, the data is also presented on an LCD display, providing a local means of visualizing the real-time results.

3.5 Summary

The suggested methodology to developing a water quality monitoring system entails a methodical approach that includes study design, data collecting techniques, sample selection, data analysis processes, ethical concerns, resource allocation, scheduling, and constraints. The equipment section emphasizes the need of choosing suitable sensors, such as the DS18B20 for temperature sensor, the E-201-C for pH sensor, and Analog Dissolved Oxygen Sensor for precise water quality measurements. The experiment design aims to provide a controlled environment by using electrical and mechanical setups. This transforms the monitoring equipment into a complete solution for conducting effective water quality study. The electrical configuration comprises of an Arduino Uno microcontroller that supervises water quality sensors, together with analog-to-digital converters (ADCs) for signal conversion, Wi-Fi connection, and a tailored power supply system. The mechanical configuration comprises a watertight casing designed to safeguard the sensors, with a strong emphasis on regular maintenance and calibration to ensure long-term precision. The components responsible for data collecting, processing, and transmission are emphasized as vital for delivering dependable and accurate data. The process involves the use of a sensor for detection, an Arduino Uno for processing, and data transfer to the Blynk app via an ESP8266 module. Additionally, the data is concurrently displayed on an LCD screen to provide real-time viewing. This integrated method creates a holistic solution for efficient water quality monitoring.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The expected outcome of the experiment is to determine the optimal temperature, dissolved oxygen, and pH ranges for producing the highest quality Tilapia fish. This information will assist the tilapia cultivator in instituting precise water quality control measures to minimise degradation and decomposition and improve fish growth, health, and overall sensory characteristics. By elucidating the relationship between water quality parameters and fish quality, this study will aid in enhancing management practises and assuring optimal Tilapia farming outcomes.

4.2 Result and Analysis

The Results and Analysis section of a water quality monitoring study serves as a pivotal component, elucidating the findings derived from the operational data of the monitoring device. This segment begins by systematically presenting the raw data through tables encompassing key parameters such as pH, dissolved oxygen, and temperature. Comparisons with established water quality standards help evaluate the conformity of the collected data with regulatory guidelines. Temporal and spatial trends are scrutinized to unveil variations over time and among different sampling locations. So, Table 4.1 shows the data was collected for the Tilapia pond by using the monitoring device.

Table 4.1: The data from the monitoring device at Tilapia pond.

Hours	Temperature (°C)	pH	DO (mg/L)
06:00	25.56	4.42	2
07:00	26.25	6.08	2
08:00	26.31	6.45	3
09:00	26.38	8.12	3
10:00	26.78	3.23	3
11:00	26.95	5.46	2
12:00	27.62	7.55	3
13:00	27.62	4.75	3
14:00	27.57	3.50	4
15:00	27.44	7.60	4
16:00	27.31	8.01	4
17:00	27.25	7.12	5
18:00	27.12	6.27	5
19:00	26.94	5.44	4
20:00	26.88	4.30	3
21:00	26.81	6.05	3
22:00	26.75	5.46	3
23:00	26.62	7.20	2
24:00	26.62	8.34	2

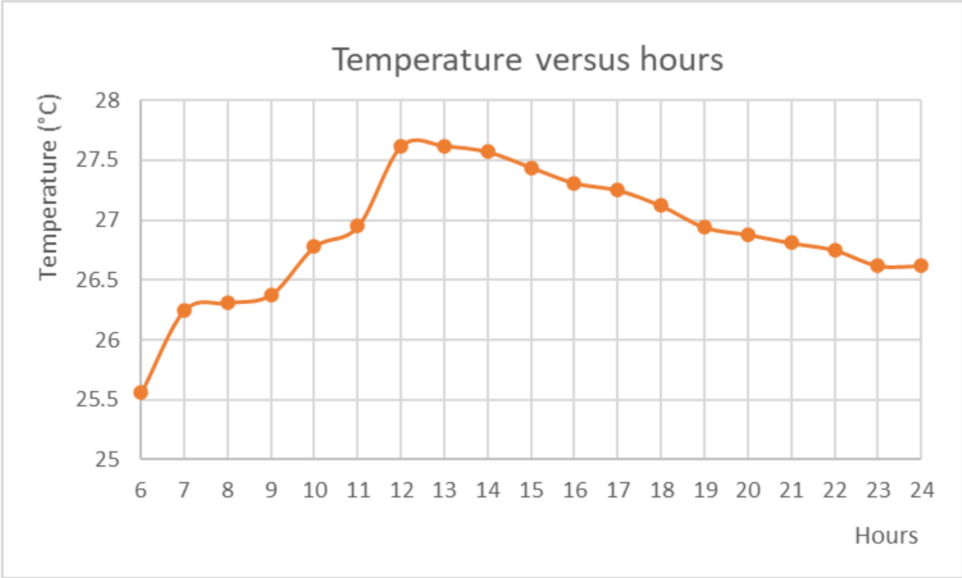


Figure 4.1: Graph the data of temperature versus hours.

Figure 4.1 illustrates the dynamic variations in temperature occurring in the tilapia pond. It shows the hourly variation in water temperature, reflecting the various changes that occur throughout the day. The observed temperature changes are clearly affected by temporal circumstances, and the surrounding environment plays a crucial role in generating these oscillations. The maximum recorded temperatures, especially at 1200 and 1300 hours, reach a peak of 27.62 °C, indicating a correlation with environmental elements that are prominent at noon. In contrast, the lowest temperature is reported around 0600 in the early morning due to the comparatively colder situations in the surroundings. Furthermore, around 14 hours, there is an apparent drop in temperature in the surface layers of the water, suggesting that the temperature sensor is working well and providing correct readings. The temperature sensor to accurately capture the complex thermal changes in the pond region is confirmed by the observed correlation with expected temperature variations in both water and air conditions.

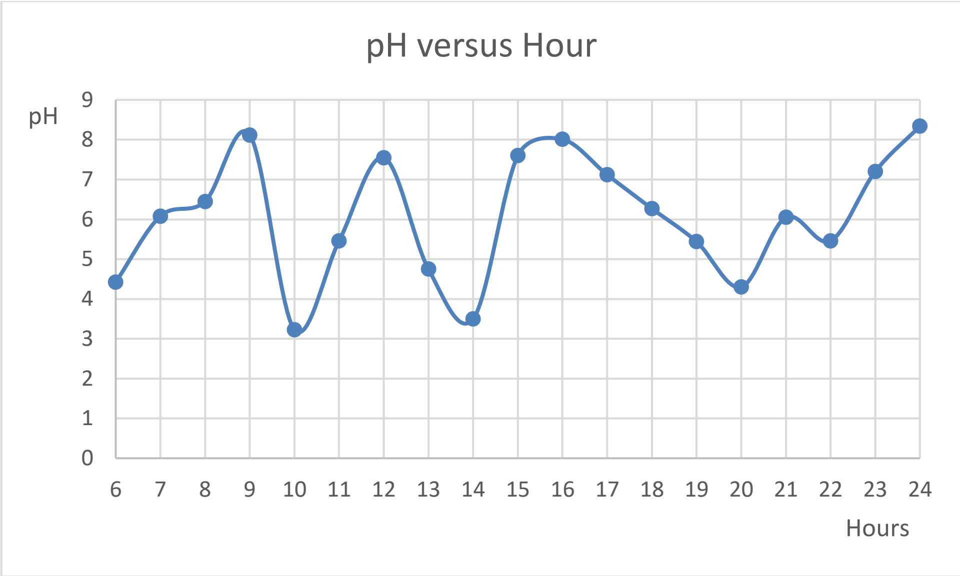


Figure 4.2: Graph the data of pH value versus hours.

The graph in Figure 4.2 shows the pH sensor data. The graph indicates an inconsistent and uneven change in the pH value per hour. Plotting is shown on the graph of down and upon substantial variations in this graph. The pH value, for instance, is 3.23 at 1000 hours and 8.12 at 0900 hours. This proved that the pH sensor is unable to reliably determine the pond's acidity level. Unstable fluctuations in the graph values might indicate a malfunctioning pH sensor that produces inaccurate value readings. This is because, based on the research, the pH value will remain constant and on a set scale to guarantee that their Tilapia are no longer in an acidic or alkaline condition.

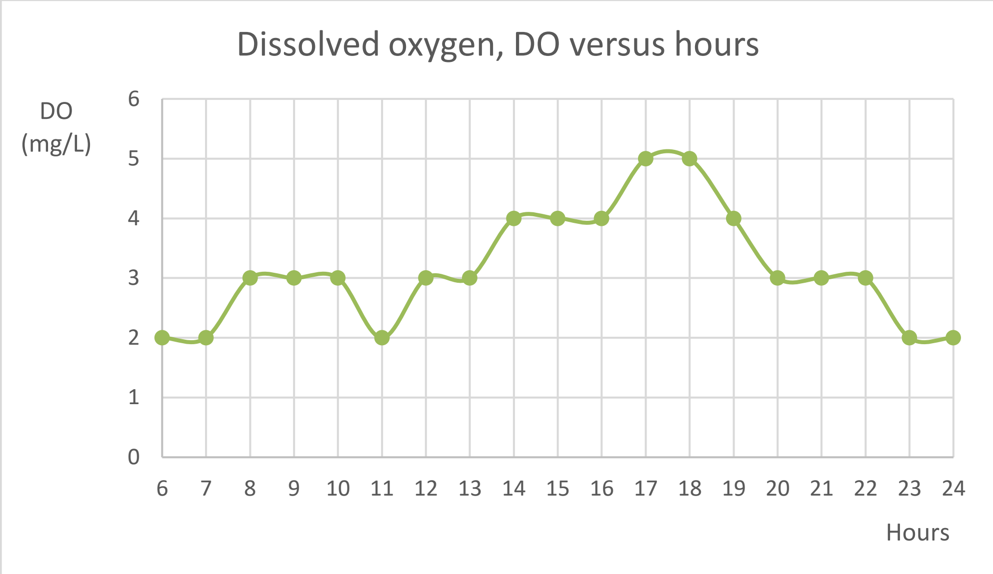


Figure 4.3: Graph the data of dissolved oxygen versus hours.

An overview of the oxygen concentration in a tilapia pond's water is shown in Figure 4.3, which shows a graph that requires changes for improved stability. There are not many ups and downs in the graph, which suggests that adjustments are necessary to have a more stable pattern. It shows that the dissolved oxygen (DO) sensor is capable of identifying values even in situations that are generally stable, despite this need for development. The graph shows the highest dissolved oxygen (DO) readings in 1700 and 1800 hours, which reach 5 mg/L, and the lowest readings at 0600, 0700, 1100, 2300, and 2400 hours, which have a minimum value of 2 mg/L. On further review, however, variations in the accuracy of the data on the graph become apparent, indicating possible mistakes in the calibration of the sensor. The inconsistent results highlight the sensor's present inability to provide accurate readings, highlighting the need for attention to correct calibration issues and improve the dissolved oxygen data collection process' accuracy.

4.3 Summary

The study of tilapia pond water quality, as illustrated in the section result and analysis provides valuable insights into the dynamic interactions between environmental conditions and sensor performance. temperature data reveals a well-functioning temperature sensor, capturing hourly variations that align with expected changes throughout the day. The relationship between the recorded temperature and the environmental elements indicates the accuracy of the sensor. On the other hand, pH data reveals inconsistencies in the pH sensor data, indicating possible malfunctions or calibration errors that affect its reliability. This finding is critical because pH stability is essential for the well-being of Tilapia. DO data illustrates dissolved oxygen levels, showing potential improvements in sensor calibration to improve accuracy. The study emphasizes the importance of proper water quality monitoring for successful Tilapia cultivation, emphasizing the need for further attention to sensor calibration to ensure optimal conditions for fish growth, health, and overall quality.

CHAPTER 5

CONCLUSION AND RECOMANDATION

5.1 Conclusion

Fish farming is seen as a crucial solution to the decline in wild fish stocks caused by pollution in rivers and lakes.The growing of fish in facilities such as ponds provides a regulated environment, which ensures that the fish will be able to survive and contribute to the stability of the food supply. However, it has been observed that a significant number of fish farms often fail to prioritize the monitoring of water quality, which is crucial for the health and happiness of the fish.

Based on the findings of this study, it has been found that fish farmers have suffered losses as a result of the absence of frequent monitoring of water quality. On the other hand, they engage in costly inputs such as fish feed without first verifying that the water conditions are sufficient for the survival and growth of fish. It is because of this supervision that fish farming becomes more expensive and less profitable. The study highlights the need of real-time monitoring and early action in response to changes in the environment in order to solve this problem. From a basic position, the viability and profitability of fish farming are directly proportional to the degree to which changes in water quality are regularly monitored and quickly handled.

In the study, the researcher explored how water quality affects fish and discussed the limitations of existing methods for monitoring water quality in fish ponds. The researcher successfully addressed these limitations by suggesting and testing a new model. The researcher favored using the IoT for real-time remote monitoring, highlighting its accessibility at any time. Additionally, the choice of a smartphone for monitoring was based on its widespread use, even in rural areas. The proposed model was effectively put into action and tested. This model offers a technological solution for monitoring water quality in real-time. In simpler terms, the researcher found better ways to keep an eye on the water conditions in fish ponds by using modern technology IoT ensuring constant monitoring and quick response to any changes.

The results and analysis section reveals that the monitoring devices encounters specific challenges that need overcome. While conducting tests in tilapia ponds, it became apparent that the pH sensor in the device is easy to make mistakes, resulting in imprecise measurements and disruptions that prevent the maintenance of a consistent value. Another noticed concern relates to the calibration, which deviates from the established standards. The lack of accuracy in calibration may lead to inaccurate data retrieval, raising concerns about the dependability of the data produced for users like DO sensors. Although these issues, it is worth mentioning that some sensors, such as the temperature sensors, continue to provide precise measurements. This suggests that the monitoring equipment is operational, but it has to be handled in order to correct the reported problems for continued and efficient long-term use.

In conclusion, the first objective of developing an IoT-Based Monitoring System for Water Quality in Tilapia Farming has been successfully achieved. However, the second objective, which aimed to ensure the proper functioning of the monitoring device for water quality solutions by implementing an IoT-based monitoring system and delivering accurate and precise values to farmers, has not been achieved. This limitation arises from the monitoring device's inability to deliver precise values for monitoring water quality in tilapia farming.

5.2 Recommendations

According to a comprehensive review of the relevant literature and expert consultations, it is obvious that a variety of additional factors necessitate attention for the purpose to protect the fish. To transform the model into a completely operational system, extra sensors may need to be installed. Exploration of methods to provide extended power to devices in remote locations is a feasible course of action for future implementations. Applying the concept of redundant devices could further reduce the repercussions of sensor failures. Furthermore, the monitoring device is imperative to recalibrate the device using the tools specified in the established standards. This recalibration process is crucial to enhance the accuracy and reliability of the values displayed by the device, establishing confidence in pond farmers. The improved precision in readings facilitates easy monitoring, allowing for the rapid detection of problems that may have a negative influence on tilapia fish market. Additionally, mitigating errors in the sensor is paramount, and this can be achieved by employing higher quality sensors and conducting thorough assessments to ensure their functionality. This approach is instrumental in preventing potential damage to the sensors.

5.3 Project Potential

The proposed research, Development of an IoT-Based Monitoring System for Water Quality in Tilapia Farming, has great potential for solving the critical problem of maintaining ideal water conditions for sustainable tilapia farming. The research is set to make important contributions to Tilapia farmers by developing the monitoring device. The projected effects include an increase in the Tilapia market, which will have an influence on farmers. Overall, the research has the potential to optimize tilapia farming for effective production and exceeding market expectations, while also making a significant contribution to academic and society.

REFERENCES

Abd El-Hack, M. E., El-Saadony, M. T., Nader, M. M., Salem, H. M., El-Tahan, A. M., Soliman, S. M., & Khafaga, A. F. (2022). Effect of environmental factors on growth performance of Nile tilapia (Oreochromis niloticus). In *International Journal of Biometeorology* (Vol. 66, Issue 11, pp. 2183–2194). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s00484-022-02347-6

Alchalaby, N. A. A., Hasan, I., Abdul, N., Salih, J., Hasan, I. J., & Abdulkhaleq, N. I. (2019). Design and implementation of a smart monitoring system for water quality of fish farms Optimum Substation Placement and Feeder Routing Using GA-MST View project Optimum Distributed Generation Allocation Using PSO in order to Reduce Losses and Voltage Improvement View project Design and implementation of a smart monitoring system for water quality of fish farms. *Indonesian Journal of Electrical Engineering and Computer Science, 14*(1), 45–52. https://doi.org/10.11591/ijeecs.v14.i1.pp45-52

AnnJil Chong. (2023, May 5). Aquaculture Industry In Malaysia: Challenges And Issues. *Maritime Fairtrade*.

Banjao, J. P. P., Villafuerte, K. S., & Villaverde, J. F. (2020, December 3). Development of Cloud-Based Monitoring of Abiotic Factors in Aquaponics using ESP32 and Internet of Things. *2020 IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management, HNICEM 2020*. https://doi.org/10.1109/HNICEM51456.2020.9400083

Bonnie Waycott. (2015). How to Maintain Good Water Quality on Your Tilapia Farm. *TheFishSite*.

Harun, Z., Reda, E., & Hashim, H. (2018). Real time fish pond monitoring and automation using Arduino. *IOP Conference Series: Materials Science and Engineering*, *340*(1). https://doi.org/10.1088/1757-899X/340/1/012014

Hasani, Q., Murti Pratiwi, N. T., Wardiatno, Y., Effendi, H., Yulianto, H., Yusuf, M. W., Caesario, R., & Farlina. (2021). Assessment of water quality of the ex-sand mining sites in Pasir Sakti Sub-District, East Lampung for tilapia (Oreochromis niloticus) culture. *Journal of Degraded and Mining Lands Management*, *8*(4), 3007–3014. https://doi.org/10.15243/JDMLM.2021.084.3007

Hidayati, D., Nurtjahyani, S. D., Oktafitria, D., Ashuri, N. M., & Kurniallah, W. (2019). Short communication: Evaluation of water quality and survival rate of red tilapia (Oreochromis Niloticus) by using rice-fish culture system in quarry land of clay. *Biodiversitas*, *20*(2), 589–594. https://doi.org/10.13057/biodiv/d200240

Koritsoglou, K., Christou, V., Ntritsos, G., Tsoumanis, G., Tsipouras, M. G., Giannakeas, N., & Tzallas, A. T. (2020). Improving the accuracy of low-cost sensor measurements for freezer automation. *Sensors (Switzerland)*, *20*(21). https://doi.org/10.3390/s20216389

La Madrid, J. D., Cruz, J. C. D., & Balisi, V. L. Q. (2019, March 12). Real-time water quality monitoring system with predictor for tilapia pond. *2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management, HNICEM 2018*. https://doi.org/10.1109/HNICEM.2018.8666423

Lee, C., & Wang, Y. J. (2020). Development of a cloud-based IoT monitoring system for Fish metabolism and activity in aquaponics. *Aquacultural Engineering*, *90*. https://doi.org/10.1016/j.aquaeng.2020.102067

Lin, J. Y., Tsai, H. L., & Lyu, W. H. (2021). An integrated wireless multi-sensor system for monitoring the water quality of aquaculture. *Sensors*, *21*(24). https://doi.org/10.3390/s21248179

Megat, A. U. A. F., & Sairul, I. S. (2021). DEVELOPMENT OF REAL-TIME WATER QUALITY MONITORING SYSTEM OF TILAPIA FISH FARMING. *Malaysian Journal of Industrial Technology*, *5*. www.mitec.unikl.edu.my/mjit

Mohd Khairul. (2023, February 12). *Lima Jenis Ikan Tilapia Di Malaysia Wajib Anda Tahu*. Ternakan Ikan.

Nanyanzi, D. R., Ocen, G. G., Omara, T., Bwire, F., Matovu, D., & Semwogerere, T. (2021). Design and assembly of a domestic water temperature, pH and turbidity monitoring system. *BMC Research Notes*, *14*(1). https://doi.org/10.1186/s13104-021-05578-9

Othman, N. A., Damanhuri, N. S., Syafiq Mazalan, M. A., Shamsuddin, S. A., Abbas, M. H., & Chiew Meng, B. C. (2020). Automated water quality monitoring system development via LabVIEW for aquaculture industry (Tilapia) in Malaysia. *Indonesian Journal of Electrical Engineering and Computer Science*, *20*(2), 805–812. https://doi.org/10.11591/ijeecs.v20.i2.pp805-812

Rennel, M., & Molato, D. (2022). AquaStat: An Arduino-based Water Quality Monitoring Device for Fish Kill Prevention in Tilapia Aquaculture using Fuzzy Logic. In *IJACSA) International Journal of Advanced Computer Science and Applications* (Vol. 13, Issue 2). www.ijacsa.thesai.org

Sajal Saha, Rakibul Hasan Rajib, & Sumaiya Kabir. (2018). IoT Based Automated Fish Farm Aquaculture Monitoring System. *2nd Int. Conf. on Innovations in Science, Engineering and Technology (ICISET)*, 1–6.

Steve A. Obado. (2019). *IoT Based realtime fish pond water quality monitoring model* [Strathmore University]. http://su-plus.strathmore.edu/handle/11071/6710

United Nations Population Fund. (2023). *Our growing population*. United Nations Population Fund.

Wongmeekaew, T., Boonkirdram, S., & Phimphisan, S. (2019). Wireless sensor network for monitoring of water quality for pond tilapia. *Proceedings - 2019 12th International Conference on Ubi-Media Computing, Ubi-Media 2019*, 294–297. https://doi.org/10.1109/Ubi-Media.2019.00064

APPENDICES

Appendix A**: Gantt Chart PSM 1**

PSM 1 Schedule			22/3/2023 Start date					21/6/2023 End date					11/1/2024 Last update date				
Development of an IoT-Based Monitoring System for Water Quality in Tilapia Farming.																	
Task		Plan vs Actual	W1	W2	W3	W4	W5	W6	W7	W8	W9	W 10	W 11	W 12	W 13	W 14	
1.	Discussion With Supervisor and Site Visit the Tilapia Farming	Plan															
		Actual															
2.	Literature Review	Plan															
		Actual															
3.	Determination of The Topic and Objectives of The Project	Plan															
		Actual															
4.	Preparation of Progress Report	Plan															
		Actual															
5.	Report Chapter 1	Plan															
		Actual															
6.	Report Chapter 2	Plan															
		Actual															
7.	Analysis Parameter of Water Quality and Type of Sensor	Plan															
		Actual															
8.	Report Chapter 3	Plan															
		Actual															
9.	Expected Result and Conclusion for PSM 1	Plan															
		Actual															
10.	Submission of Draft Final Report PSM 1	Plan															
		Actual															
11.	PSM 1 Seminar	Plan															
		Actual															

Appendix B: Gantt Chart PSM 2

PSM 2 Schedule		**11 October 2023** Start date						**17 January 2024** End date						**11 January 2023** Last update date		
Development of an IoT-Based Monitoring System for Water Quality in Tilapia Farming.																
Task		**Plan vs Actual**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W 10**	**W 11**	**W 12**	**W 13**	**W 14**
1.	Discussion with the Supervisor and Site Visit to the Tilapia Farming for the Second Time	Plan														
		Actual														
2.	The Type of Sensor and Microcontroller Preparation	Plan														
		Actual														
3.	Constructing Electronic Devices	Plan														
		Actual														
4.	Collect the Data and Analysis	Plan														
		Actual														
5.	Result and Discussion	Plan														
		Actual														
6.	Preparation of Progress Report	Plan														
		Actual														
7.	Report Chapter 4	Plan														
		Actual														
8.	Report Chapter 5	Plan														
		Actual														
9.	Final Report Writing	Plan														
		Actual														
10.	Submission of Draft Final Report	Plan														
		Actual														
11.	PSM 2 Seminar	Plan														
		Actual														

Appendix C: Tilapia Farming at Alai, Melaka

Appendix D : Monitoring Device Setup.