SENSOR DURABILITY AND CALIBRATION OF A RTCS BASED ON REAL-TIME COLLECTION

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BACHELOR OF TECHNOLOGY MECHANICAL ENGINEERING TECHNOLOGY (BMMV) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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DECLARATION

I declare that this thesis entitled " Sensor durability and calibration of a RTCS based on real-time data collection" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Nurfatin Amirah Binti Abdullah

Date : 10/01/2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Technology Mechanical Engineering Technology (BMMV) with Honours.

Signature : 

Supervisor Name : Sayed Kushairi Bin Sayed Nordin

Date : 20.1.2023

DEDICATION

This final year project is dedicated to my parents, who are the motivating factor behind my efforts to complete it successfully. This project is also dedicated to my supervisor, Sayed Kushairi Bin Sayed Nordin, and my co-supervisor, TS. Mohd Idain Fahmy Bin Rosley, for their endless hours of reflection, reading, encouraging, and, most importantly, patience throughout the process.

ABSTRACT

Water contamination has become a severe concern as a result of increasing water-related activities such as transportation, fishing, and entertainment. It jeopardises human and ecological health, as well as the quality of the water in the surrounding region. The goal of the River Garbage Collector System (RTCS) project is to create a system that can collect floating trash, oil, gasoline, and detergents from water bodies. As a consequence, the water pollution problem will be resolved, and the River, as one of the most importance ecosystems, as well as its marine life, will be protected. It has a sensoring system for evaluating water quality as well as a waste weight restriction. Sensors are crucial in the development of IoT solutions. Sensors are devices that detect and replace external data with a signal that humans and machines can understand. Sensor will make the data collection be much easier rather than manual collection. . By the completion of the research, a fully functional garbage collector should be removing debris along the Malacca River's shoreline. This newly constructed RTCS will also help with water pollution concerns, notably along the River.

ABSTRAK

Pencemaran air telah menjadi kebimbangan yang teruk akibat peningkatan berkaitan air aktiviti seperti pengangkutan, memancing, dan hiburan. Ia membahayakan manusia dan kesihatan ekologi, serta kualiti air di kawasan sekitar. Matlamat untuk projek River Trash Collector System (RTCS) adalah untuk mewujudkan satu sistem yang boleh mengumpul sampah terapung, minyak, petrol, dan detergen daripada badan air. Akibatnya, air masalah pencemaran akan dapat diselesaikan, dan Sungai, sebagai salah satu ekosistem yang paling penting, serta hidupan marinnya, akan dilindungi. Ia mempunyai sistem penderiaan untuk menilai kualiti air serta sekatan berat sisa. Penderia adalah penting dalam pembangunan penyelesaian IoT. Penderia ialah peranti yang mengesan dan menggantikan data luaran dengan isyarat yang boleh difahami oleh manusia dan mesin. Sensor akan menjadikan pengumpulan data menjadi lebih mudah daripada pengumpulan manual. . Menjelang selesainya penyelidikan, pemungut sampah yang berfungsi sepenuhnya harus mengalihkan serpihan di sepanjang pantai Sungai. RTCS yang baru dibina ini juga akan membantu dengan masalah pencemaran air, terutamanya di sepanjang Sungai.

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My supervisor, Sayed Kushairi Bin Sayed Nordin, and also my CO-Supervisor, TS. Mohd Idain Fahmy Bin Rosley, deserves my gratitude for their support, encouragement, counsel, and inspiration. Their patience in guiding and providing crucial insights will be remembered for the rest of their life. They also shares many of their experiences from their time in the field and continues to offer aid for a better understanding.

Finally, I'd like to express my gratitude to my loving parents for their unwavering support, love, and prayers. Finally, I'd like to express my gratitude to all of the people, particularly my friends, who have assisted, supported, and inspired me to begin my Bachelor Project.

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LIST OF SYMBOLS AND ABBREVIATIONS

RTCS	-	River Trash Collector System
ANOVA	-	Analysis Of Variance
TDS	-	Total Dissolved Solid
DO	-	Dissolved Oxygen

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CHAPTER 1

INTRODUCTION

1.1 Background

Hundreds of aquatic species have been discovered dead along the historic Sungai Melaka canal following a significant pollution event caused in part by industrial waste discharge.According to Malaysian press sources, pollution has killed thousands of fish in the Malacca River, rendering its waters "black and foul-smelling". In an effort to wash the filthy water out to sea, PPSPM opened the dam at the river's mouth around midnight on Tuesday (May 21). Around 60 PPSPM personnel have also been deployed to help clean up the dead fish before they fall to the river's bottom.

Water supplies have been decreased in the recent year. According to worldwide water pollution statistics, developing nations produce 70% of untreated industrial wastes that end up in water, and they use an average of 99 million pounds (45 million kilogrammes) of fertiliser and chemicals each year (National Geographic Portal, 2016). In the Malacca River, this is a regular occurrence. The river is now poisoned, resulting in the extinction of several fish species. Law enforcement, water resource regulations, religious and moral teaching, and public awareness about the importance of the environment, particularly riverine water resources, have all been adopted by the state government. However, the state government's adoption of such programs to protect river water quality has not resulted in lower levels of water contamination. The situation has grown more dangerous as it has progressed to a higher level. As a result, the principal pollutants emitted by the major sources of pollution

should be researched and quantified, particularly in terms of geographical variation in the Malacca River. Several systems for monitoring and analyzing river water have been designed and marketed. The Malacca River, on the other hand, has yet to be implemented due to a lack of information or technological know-how.

1.2 Problem Statement

Water is a vital component of human life that must be used in daily activities while also satisfying the needs of business and ecosystems. Liquids, solids, and gases can all make up the water component. The essential qualities that are highlighted so that there are no adverse effects to humans and other living species are clean, safe water sources. Rivers, oceans, and lakes are examples of natural water sources. Rivers are important for removing urban and industrial effluent from rural areas. However, due to the amount of waste generated by human activities, the river system frequently suffers from water pollution issues. Contaminants turn bodies of water unsafe for human consumption while also disrupting aquatic ecosystems. To mention a few examples, Toxic waste, gasoline, and disease-causing bacteria are among contaminants that may contaminate water.

In surface waterways, trash, litter, and rubbish are common sources of solid waste. In metropolitan settings, stormwater runoff is commonly used to move trash and waste. People who fish or engage in water-related leisure also produce trash. Trash, regardless of its source or sort, pollutes water. Some people continue to dump unneeded items, such as couches and beds, in waterways. Some abandoned goods, ironically, provide home for aquatic species. Trash, on the other hand, is unattractive and an indication of human disrespect for aesthetic standards and natural ecosystems.

One of the main sources of water pollution in the Malacca River is the state of Malacca's rapid development. This can be seen in the changes in water quality as a result of the modernization that is taking place without any constraints or restrictions. As depicted in Figure 1, river water is becoming progressively contaminated, blackish, and emitting an awful stench. The Malacca River is one of the tourism attractions, so this scene is really disappointing to exhibit to visitors.

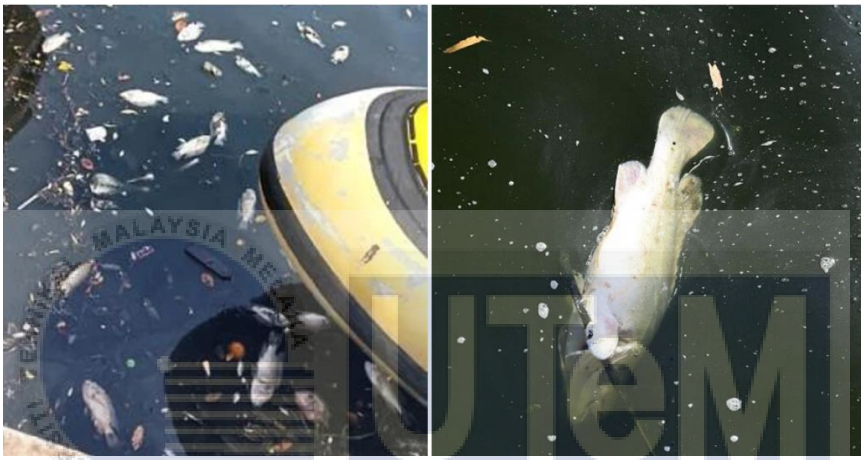


Figure 1.1 Water Pollution at Malacca River

1.3 Research Objective

The research paper focuses on the following specific objectives in order to fulfil its ultimate aim of collecting trash at the Malacca River:

- To develop sensoring system for RTCS
- To optimize sensoring system for RTCS
- To compare if there is a significance different of pH,DO, turbidity, TDS and temperature of water in different time

1.4 Scope of Research

- This study will be implemented using sensoring system.
- This study will be implemented using low-cost devices integrated with the Internet of Things (IoT) to facilitate remote monitoring the sensor to get data.
- This study will be conducted in the Malacca River area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Background research and a literature evaluation are included in this chapter throughout the project, with articles, book reviews, and journals serving as resources. This chapter will focus on the difficulties of water pollution as well as all of the materials that will be used in River Trash Collecting System (RTCS). It will also do a literature review on the SLS 3D printing machine as well as all of the sensors that will be used. With the help of the literature review, this section will explain the project in greater detail and make it easier to understand.

2.2 Water Pollution

Water is a renewable resource that is required for all forms of life, as well as food production, economic growth, and overall well-being. It is difficult to clean and transport, and it is definitely a one-of-a-kind natural gift (Singh & Gupta, 2017). As a result of rapid population increase and industrialisation, the demand for freshwater has risen considerably in recent decades (Ramakrishnaiah et al., 2009). Water contamination may be classified into two types: point and non-point. A point source is pollution that has a single identifiable source. Pollution released into the environment in one place can have an impact hundreds, if not thousands, of kilometres elsewhere. Cross-border pollution is the term for this. Pollution may occur when large volumes of foreign particles enter the environment (Bin Zakariah et al., 2022).

River polluted water has gotten a lot of attention in recent years, and it continues to be a major source of concern around the world. The deterioration of water quality is primarily

linked to the issue of population development and city expansion. This is a threat to human and ecological health, as well as the supply of drinking water and economic development (Li & Zhang, 2010). Human activities that provide a financial benefit to society have harmed the river's water quality indirectly (Muyibi et al., 2008).

2.3 Water Quality

After air, water is likely the most valuable natural resource, yet it is also a finite resource. Water's appropriateness for usage must be examined before it is drunk or bathed, as it is required for a variety of usesWater quality refers to the chemical, physical, and biological characteristics of water, as well as its suitability for a particular application. Recreation, drinking, fishing, agriculture, and industrial uses are all possible with water. Drinking water and swimming water, for example, are held to far higher standards than water used in agriculture and industry (Roy, 2018). States and authorized tribes are responsible for setting water quality standards that "...consist of the designated uses of the navigable waters concerned and the water quality criteria for such waters based on such uses," according to Section 303(c)(2)(A) of the CWA. "...protect the public health or welfare, improve the quality of water, and serve the goals of this Act," according to the criteria (USEPA, 2017).

According to the World Health Organization, millions of people suffer from a variety of ailments as a result of drinking contaminated water (WHO). Drinking clean, safe water has been linked to better health results around the world. As a result, determining the water use potential of any water supply is critical (Madilonga et al., 2021).

Human civilisation, industrial, and agricultural activities are the primary contributors of water contamination. Unsanitary disposal and poor treatment of human and animal wastes are two negative aspects of these operations. These contaminants will poison the water

system whether they are discharged directly or indirectly into water bodies. (Obilonu et al., 2013). Increased acidity, higher concentrations of nutrients, sediments, salts, trace metals, chemical and other pollutants, as well as hazardous pathogenic organisms that flourish in warmer temperatures, are all signs of pollution and contamination from such sources. Nutrient enrichment has become one of the most common water quality issues, wreaking havoc on freshwater and coastal ecosystems (UNESCO, 2009)

2.4 Sensor

A sensor is an electronic device that receives a signal or stimulus and replies with an electrical signal. Some types of electrical signals, such as current or voltage, are represented by the output signals. Based on the application, input signal, and conversion method, sensors are divided into distinct categories (Vetelino & Reghu, 2017).

2.4.1 Analog TDS Sensor

A TDS meter is a compact hand-held device that measures the amount of Total Dissolved Solids (TDS) in a solution, often water. TDS is the proportion of all inorganic and natural substances present in water in various forms that has been disintegrated and consolidated. TDS is used to indicate the taste of water. The presence of chemical pollutants in water is indicated by TDS (Kondle et al., 2020). TDS (Total Dissolved Solids) is a measurement of how many milligrams of soluble solids are dissolved in a liter of water. The less clean the water is, the higher the TDS value. As a result, it can be used as one of the benchmarks for measuring the purity of drinking water. TDS is measured in parts per million (ppm) or milligrams per liter (mg/l). The allowable TDS limit is 500 ppm. The TDS value of the sample water is within the acceptable range, being as low as 161. This product accepts a wide voltage range of 3.3 to 5.5V and outputs a 0 to 2.3V analogue voltage, making it

suitable with 3.3V and 5V control systems. This water-resistant probe can be submerged in water for long periods of time to test TDS readings (Ragavan et al., 2016).

2.4.2 Temperature Sensor

Temperature sensors are used in a wide range of products and services, including everything from domestic appliances to medical devices. Humans are surrounded by temperature sensors. They monitor the temperature of HVAC systems, refrigerators, freezers, and computers in our buildings and houses. Temperature is constantly monitored and controlled in industrial applications such as motor controls, assembly lines, processing, and manufacturing. Temperature sensors come in a variety of shapes and sizes, as well as a variety of functions, making them ideal for a variety of applications. Resistance temperature detectors (RTDs), local temperature sensor ICs, and remote thermal diode measuring ICs are the most often utilized in modern electronics ("Temperature Sensor," 2001). The resistance temperature detector (RTD, also known as a resistance thermometer) is a popular temperature sensor. RTDs are noted for their great accuracy and precision. Due to the degradation of the outer sheath, which holds the thermometer, RTDs become exceedingly inaccurate at high temperatures (C. Sensors, 2007).

2.4.3 Analog Dissolved Oxygen Sensor

Analog Dissolved Oxygen Sensor is used to assess water quality by measuring the amount of dissolved oxygen in the water. Aquaculture, environmental monitoring, natural science, and other water quality applications use it extensively (Robotshop, n.d.). It is used to determine the amount of dissolved oxygen in water and thus the water quality. This sensor kit makes it easy to make your own dissolved oxygen detector rapidly. The probe is galvanic, requires no polarization time, and is always available. The probe must be calibrated for

accuracy in most circumstances. The probe is calibrated with saturated dissolved oxygen and zero dissolved oxygen in the single point calibration (H. Sensors et al., 2017). At atmospheric pressure, oxygen has a temperature-dependent solubility that changes as water vapor reaches 100% at boiling. If the pressure over the water was increased, the entire curve would shift upwards. Aerobic machines, on the other hand, rely on partial vacuum and increased temperatures to remove dissolved gases (Gray, 2002).

2.4.4 Analogue pH Sensor

The pH of a solution is measured using an analogue pH meter, which reflects the acidity or alkalinity of the solution. It's commonly utilized in aquaponics, aquaculture, and environmental water testing, among other things (Cytron Technologies Sdn. Bhd., 2019). The PH scale runs from 0 to 14. Where PH 0 is extremely acidic, PH 7 is neutral, and PH 14 is extremely alkaline. The water has a PH of about 7, and it's around this point that we'll need to keep track of the PH of a variety of items. For example, a swimming pool should be somewhat alkaline around 7.2, hydroponics systems should be around 6 (for optimal plant nutrient uptake), and aquaponics should be about 6.8 (Santaefiigenia, 2017).

The exchange of ions from sample solution to inner solution (pH 7 buffer) of glass electrode across the glass membrane is the overall operating concept of pH sensor and pH meter. With continued usage, the porosity of the glass membranes decreases, lowering the probe's performance. When the probe is submerged in a solution, hydrogen ions form a ring around the bulb, displacing the metal ions. As the acidity of the solution rises, so does the concentration of hydrogen ions in the solution, which raises the voltage. As a result, the voltage increased and the pH value in the pH metre plummeted.

2.4.5 Turbidity Sensor

The Arduino turbidity sensor evaluates water quality by measuring the turbidity, or opaqueness, of the water. Water quality in rivers and streams is measured using turbidity sensors. This liquid sensor can output both analogue and digital signals (DFRobot Electronic, 2018). The presence of turbidity in a liquid indicates that it has been contaminated. Turbidity in water can only be evaluated by sampling during the testing procedure. To maintain water quality, a tool was needed that could monitor and measure the turbidity of the water in real time.

The SEN0189 water turbidity sensor measures the amount of light emitted by an infrared led into the phototransistor, which generates the sensor's output voltage (Hakim et al., 2019). Water quality in rivers and streams, wastewater and effluent measurements, control instruments for settling ponds, sediment transport research, and laboratory measurements all use turbidity sensors (DFRobot, 2018). A light detector detects how much light is reflected to it when it is positioned at a 90-degree angle to the light source. To determine the turbidity of water, a turbidity probe fires a laser beam into it. This light will subsequently be dispersed by any suspended particles.

2.4.6 Weight 50kg Sensor

This load cell half bridge 50KG weight sensor is ideal for electronic balances and other high-precision electronic weighing systems. When measuring, the right force is given to the strain E-shaped beam section of the sensor's outer side and the outside edges to create a shear force in the opposite direction (Electronics, 2015). This strain gauge, also known as a load cell, can convert up to 50KG of force into an electrical signal. Load cells are essentially transducers that measure only one force while disregarding all others. Because

the electrical signal from the load cell is so feeble, it necessitates the use of a load cell amplifier such as the HX711 load cell amplifier.

2.4.7 Water Level Float Sensor

Many of today's electronic tank monitoring equipment use float level sensors as the first-line input. Switch and continuous level float sensors monitor a specified liquid level by providing a on or off signal. Float level sensors may be relied on to produce accurate and dependable measurements, from basic on/off pumps to very sophisticated liquid indicator. A float switch is a device that detects the level of liquid in a tank. An internal magnet typically slides up and down a stem containing hermetically sealed switches. Switches are used to close or open a circuit with a little quantity of current flowing through it (Connection et al., n.d.).

2.4.8 Hall Flowmeter Sensor

Flow meters have shown to be effective tools for measuring irrigation flow. Lower-than-normal flow rates could signal a need for pump repair or pipeline leaking. To determine how much water is flowing through an irrigation pipeline, flow can be detected using a contact or non-contact type of sensor. Flow measurement is one of the most significant instruments in the hands-on engineer's arsenal, but its application is limited due to its non-linear features. To calculate flow, the technique known as ultrasonic flow measurement, a non-invasive type of measurement, is extensively utilized (Sood et al., 2013).

2.4.9 Ultrasonic Flowmeter Sensor

The ultrasonic flowmeter is used in conjunction with an ultrasonic sensor mounted on the outside of an existing pipe to convert the amount of fluid flowing through it into a unified current signal and integrated pulse signal (DORY, 1970). Ultrasonic flowmeters

(USFM) have become more essential in the monitoring of fluid flow. USFMs can be used as a clamp-on metre or as a spool-piece metre. Many articles try to increase the flowmeter's accuracy (Ma et al., 2012). A repeating voltage pulse is applied to the transducer crystals to generate an ultrasonic beam of a specific frequency. The velocity of the liquid through the pipe accelerates the speed at which the ultrasound is transferred through the liquid. The liquid flow velocity is directly proportional to the time difference T1 – T2 (Ma et al., 2012).

2.5 Internet of Things (IoT)

In recent months, it's been nearly difficult to avoid hearing the term "Internet of Things" (IoT) in some form or another. Particularly in the last year, there has been a remarkable increase. There has been a spike in interest in the Internet of Things. Several IoT-based goods and services have begun to be introduced by businesses. Modern technologies, such as the Internet of Things (IoT), can be used in a variety of ways in the energy industry, including energy production, transmission, distribution, and consumption. The Internet of Things can be used to improve energy efficiency, increase renewable energy use, and reduce environmental impacts (Motlagh et al., 2020).

With embedded devices that communicate with one other, services, and people on a global scale, the Internet of Things (IoT) has the potential to replace people as the main consumer and provider of information on the Internet. By improving access to information, this level of connectivity can improve reliability, sustainability, and efficiency (Ηυανικων et al., 2009). The Internet of Things (IoT) is a concept that describes a world in which almost anything may be connected and communicate intelligently. Sensors and actuators embedded in physical things, ranging from roads to pacemakers, are connected via wired and wireless networks, frequently sharing the same Internet IP address (Madakam et al., 2015).

2.6 SolidWorks

SolidWorks is a 3D modelling tool for the Windows operating system that allows users to construct 3D complicated and functional designs. Dassault Systems SOLIDWORKS Corporation publishes and develops this 3D software. SolidWorks, along with Autodesk Inventor and Solid Edge, is one of the most prominent mechanical design software in use today (Lam et al., 2017). SOLIDWORKS® CAD is a mechanical design automation software that allows designers to swiftly sketch out concepts, experiment with features and measurements, and create models and detailed drawings (Dassault Systèmes, 2015). Solidwork is a mechanical design automation software that includes a feature-based, parametric solid modelling design tool that uses a simple Windows graphical user interface. It can construct completely associative 3D solid models with or without constraints, capturing design intent through automatic or user-defined relations (Portal, 1995). SOLIDWORKS employs a three-dimensional design technique. It creates a 3D model when designing a part, from the first concept to the final output. It may build 2D drawings or join components made up of parts or subassemblies to create 3D assemblies using this model. It can also make two-dimensional drawings of three-dimensional assemblies.

When using Solidworks to design a model, it can envision it in three dimensions, as it will be after it is manufactured (Dassault Systèmes, 2015).

2.7 SLS 3D Printer

SLS (Selective Laser Sintering) is a method of producing plastic parts by layering material in a certain order. Subtractive machining, such as drilling, milling, and grinding, is in contrast to additive manufacturing. SLS is widely recognized as the most advantageous manufacturing technology for industrial plastic parts (Schmid et al., 2015). Selective laser sintering (SLS) is an additive manufacturing (AM) technique that sinters

microscopic particles of polymer powder into a solid structure based on a 3D model using a high intensity laser. For decades, SLS 3D printing has been a popular choice among engineers and manufacturers (Formlabs, 2021). One of the first additive manufacturing processes was selective laser sintering. A variety of materials, including polymers and metals, have been developed to work with the process. Both plastic and metal powder bed fusion methods were excessively expensive and difficult until recently. SLS (selective laser sintering) is a versatile rapid prototyping (RP) technology that can manufacture complex geometries directly from digital models using a variety of powdered materials. SLS uses a laser to layer-by-layer sinter particular parts of powdered materials to create solid objects based on 2D data obtained from CT scan or MRI imaging procedures. (Saffarzadeh et al., 2016). Selective Laser Sintering has emerged as one of the most promising rapid prototyping techniques in the world. Carl Deckard and Joseph Beaman developed the technique at the University of Texas at Austin. DTM was eventually bought out by 3D Systems in 2001. SLS (selective laser sintering) is an additive manufacturing technique that involves a laser precisely fusing a bed of nylon to create a product from a 3D file. SLS pieces have a matte white surface that is slightly rough (On, 2016).

2.7.1 SLS Procedure

The SLS method fabricates models using a CO2 laser beam. The laser traces the path on the powder surface before heating it to sintering temperature. The build tray travels downward after the first layer is sintered, and a new layer of powder is deposited. Instead of having to be melted down for re-use, SLS's products may be crushed into powder and reused (Saffarzadeh et al., 2016). The most common material for selective laser sintering is nylon, a highly capable engineering thermoplastic for both functional prototype and end-use manufacture. Nylon is ideal for intricate assemblies and long-lasting, weather-resistant parts.

Nylon 3D printed goods are durable, strong, stiff, and substantial. The finished components are impact-resistant and long-lasting. (Formlabs, 2021).

The width and thickness of the wall on which the gap is produced determine the gap resolution in SLS. Because material is easier to clear through thinner walls, the resolution of gaps can be increased. Smaller gaps on big surfaces may also diminish as a result of thermal shrinking. when making a small part, make careful to utilise thinner walls with gaps to avoid over sintering. To adjust for shrinkage due to over-sintering, offset narrow or irregular gaps 0.006" – 0.008" (0.15mm – 0.20mm) and end up with a part that is closer to your designed measurements (On, 2016).

2.8 Benchmark

Table 2.1 Benchmark

System for river cleanup	Advantage	Disadvantage
River Trash Collecting System 	• Have sensor and camera to monitor from afar. • Can collect up to 50kg trash	• Need to get the trash out manually when its full.
Seabin project 	• Can hold up to 20kg rubbish	• Cam operate only in calm water • Over product's electricity usage
Waste shark 	• Small enough to get in tight areas • Can operate manually or automatically	• Could disturb the marine life • Not enough space for waste to get collected.

The reason RTCS model were chosen is because it can be monitor from a far distance and can alert us when the trash bin is full. The model is also big and can be compatible in Malacca River. It also completes with sensor system to monitor water quality and also weight of the trash. From Literature Review, we can do this design model and understand the sensor system more.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology refers to the steps involved in conducting an analysis. It is a strategy for achieving objectives through planning, data collection, investigation, and analysis in order to demonstrate that the study is valid. The research will become more methodical as a result of the approach, and the scientific route will become more focused and successful as a result of the approach. This study will show the entire process, from field research through sample collection to analysis of the results.

3.2 Project planning

This are the project planning for the River Trash Collecting System (RTCS) from start to finish.

3.2.1 Research Method

In this study, all parameter sample data for this project will be obtained along the Malacca River. The suggested river trash collection system intends to be comparable to traditional methods, which are time intensive and do not provide real-time data.

3.2.2 Research Area

This study will be conducted at Malacca River to monitor and reduce trash in the river with a collaboration with the Perbadanan Pembangunan Sungai dan Pantai Melaka (PPSPM). This device that has been developed will be place with the boat and go through Malacca River to take the trash underneath the water.

3.2.3 Flowchart

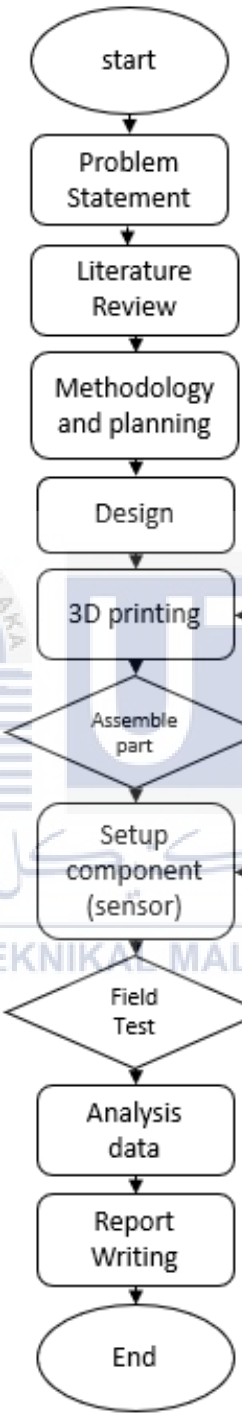


Figure 3.1 Flowchart

3.3 River Trash Collecting System

RTCS was created with the goal of reducing pollution in the area. The basic concept is based on the Seabin concept, which functions as a rubbish collector in the water. The Seabin is a garbage can that floats. Marinas, docks, yacht clubs, and commercial ports are all located on the sea. The Seabin rises and falls. Water is drawn in from the surface, passed through a catch bag inside the Seabin, and then pumped back into the marina, trapping litter and debris to be properly disposed of. The Seabin may also capture a proportion of oil and contaminants that float on the water's surface. However, for the RTCS to be linked with the State of Malacca's green technology agenda, various changes are required.

3.3.1 Sensor Components

There are several sensors that River Trash Collecting System (RTCS) used to measure the data. The following is a list of sensors used in RTCS:

I. Analog TDS Sensor
II. Temperature Sensor
III. Analog Dissolved Oxygen Sensor
IV. Analog pH sensor
V. Turbidity Sensor
VI. Weight 50KG Sensor
VII. Water Level Sensor
VIII. Hall Flowmeter Sensor
IX. Ultrasonic Flowmeter Sensor

a) Analog TDS Sensor

Analogue gravity Arduino TDS sensor/meter This is an Arduino-compatible TDS meter kit for determining the TDS value of water in order to determine its purity. It can be used to test the quality of residential water, hydroponics, and other types of water. TDS is the number of milligrams of soluble solid dissolved in water, and the less pure the water is. As a result, TDS value may be used to indicate the purity of water. Table 3.1 below shown the specification for the Total Dissolved Solid (TDS) sensor.

Table 3.1 Specification Analog TDS Sensor

	Specifications
Input Voltage	3.3 ~ 5.5 V
Output Voltage	0 ~ 2.3 V
Working Current	3 ~ 6mA
TDS Measurement Range	0 ~ 1000ppm
TDS Measurement Accuracy	± 10% F.S (25°C)
Module Size	42mm × 32mm
Module Interface	PH2.0-3P
Electrode Interface	XH2.54-2P
Number of Needle	2
Total Length	83cm
Connection Interface	XH2.54-2P

Figure 3.2 Analog TDS Sensor

b) Temperature Sensor

A temperature sensor is an electronic device that records, monitors, or signals temperature changes by measuring the temperature of its surroundings and converting the input data into electronic data. Temperature sensors come in a variety of shapes and sizes. Temperature sensor that we use for this product are DS18B20 temperature sensor and is waterproof. It is convenient for measuring anything from a distance or in rainy circumstances. The sensor can withstand temperature of up to 125°C ash shown in Table 3.2 and the features as can see in Figure 3.3, however since the wire is PVC-coated, it is recommend keeping it below 100°C. Due to their digital nature, this sensor exhibit no signal loss over extended distances.

Table 3.2 Specification Temperature Sensor

Specifications	
Module Power	3.0 ~ 5.5 V
Accuracy	-10°C ~ +85°C
Usable Temperature Range	-5 ~ 125 °C
Cable Diameter	4mm (0.16)
Length	95cm (37.4")

Figure 3.3 Temperature Sensor

c) Analog Dissolved Oxygen Sensor

The amount of dissolved oxygen in water, and consequently the water quality, is measured with this dissolved oxygen meter. Aquaculture, environmental monitoring, natural science, and other water quality applications use it. This device is used to measure dissolved oxygen in water, which is an excellent predictor of water quality. The probe is galvanic, requires no polarization time, and is always available. The membrane cap and filling solution are both interchangeable, resulting in cheap maintenance costs. This dissolved oxygen meter is very user-friendly and has a high level of compatibility as in Figure 3.4. The amount of dissolved oxygen in water, which is indicative of the water's quality.

Table 3.3 Specification Analog Dissolved Oxygen Sensor

Specifications	
Type	Galvanic Probe
Detection Range	0 ~ 20mg/L
Pressure Range	0 ~ 50PSI
Operating Voltage	3.3 ~ 5.5 V
Output Signal	0 ~ 3.0 V
Signal Connector	Gravity Analog Interface (PH2.0-3P)
Dimension	42mm × 32mm

Figure 3.4 Analog Dissolved Oxygen Sensor

d) Analog pH sensor

A pH sensor is one of the most important items of equipment for water testing. This sort of sensor can detect alkalinity and acidity levels in water and other liquids. As shown in table, the integrated voltage regulator chip provides a broad voltage range of 3.3 to 5.5V. making it compatible with both 5V and 3.3V main control boards. The output signal after hardware filtering has a low jitter. The software library employs a two-point calibration approach and is capable of automatically identifying two standard buffer solutions that is 4.0 and 7.0, making it very easy and straightforward to use. It is equipped with and industrial electrode and a built-in easy, convenient, and practical connection, making it ideal for online monitoring specification as in Table 3.4.

Table 3.4 Specification Analog pH sensor

Specifications	
Module Power	5.00 V
Module Size	43mm × 32mm (1.70” × 1.26”)
Measuring Range	0 ~14PH
Measuring Temperature	0 ~ 60°C
Accuracy	± 0.1pH (25°C)
Response Time	≤1min

Figure 3.5 Analog pH sensor

e) Turbidity Sensor

Turbidity sensors measure how much light is dispersed in water by suspended materials. The turbidity level (and cloudiness or haziness) of water increases as the amount of total suspended solids (TSS) in the water increases. This sensor determines the quality of water by monitoring its turbidity level. Table 3.5 shows the specification of turbidity sensor.

Table 3.5 Specification Turbidity Sensor

Specifications	
Operating Voltage	5V DC
Operating Current	40mA (MAX)
Response Time	<500ms
Insulation Resistance	100M (Min)
Output Method	Analog
Analog output	0-4.5V
Operating Temperature	5°C ~ 90°C
Storage temperature	10°C ~ 90°C
Weight	30g
Adapter Dimensions	38mm × 28mm × 10mm

Figure 3.6 Turbidity Sensor

f) Weight 50KG Sensor

This Load Cell Weight Sensor or strain gauge can translate up to 50KG of pressure (force) into an electrical signal. Load cells are essentially transducers that are designed to measure a single force while ignoring all other forces. When measuring the strain of an electronic sensor, it's critical to apply the necessary forces in the right direction, such as a strain gauge affixed to the middle, adhesive coating with white beam arms, and the outer borders to generate a shear force in the opposite direction. When bending, strain beam side by another force should not be a barrier because essential modifications can occur under stress.

Table 3.6 Specification Weight 50KG Sensor

Specifications	
Capacity	50 Kg
Output Sensitivity	1.0 ± 0.1 mv/v
Nonlinearity	0.03 %FS
Repeatability	0.03 %FS
Input Resistance	1000
Insulation Resistance	5000

Figure 3.7 Weight 50KG Sensor

g) Water Level Sensor

A water level sensor is a device that detects if a liquid is at a high or low level in a fixed vessel. There are two different types of liquid level measurement methods: contact and non-contact. What we refer to as an input water level transmitter is a contact measurement that converts the height of the liquid level into an electrical signal. It is currently a frequently used water level transmitter.

Table 3.7 Specification Water Level Sensor

Specifications	
Stability	0.1 % F.S
Temperature Range	0°C ~ 70°C
Operating Current	35mA
Accuracy	0.5%
Output	4-20mA

Figure 3.8Water Level Sensor

h) Hall Flowmeter Sensor

For Flow Technology positive displacement flow meters, the Hall Effect Sensor is a basic but versatile sensor. It's a magnetic field reversal-activated integrated flow meter circuit gadget. This pinwheel sensor, which monitors how much liquid has passed through it, is positioned such that it is parallel to the water line. An implanted magnetic hall effect sensor produces an electrical pulse with each rotation. The hall effect sensor is separated from the water pipe to keep it dry and secure.

Table 3.8 Specification Hall Flowmeter Sensor

Specifications	
Working Voltage	5 ~ 18V DC
Max Current	15mA
Output	5V
Flow Rate	1 to 30 L/min
Temperature range	-25°C to +80°C
Accuracy	±10%
Max water pressure	2.0 MPa

Figure 3.9 Hall Flowmeter Sensor

i) Ultrasonic Flowmeter Sensor

Sound waves are used by ultrasonic flowmeters to estimate the velocity of a fluid flowing through a conduit. The frequencies of an ultrasonic wave transmitted into a pipe and its reflections from the fluid are the same under no flow conditions. The frequency shift increases linearly as the fluid travels faster. The upstream wave goes slower and takes longer than the downstream wave in flowing conditions. The disparity between the upstream and downstream times grows as the fluid moves quicker.

Table 3.9 Specification Ultrasonic Flowmeter Sensor

Specifications	
Flow Velocity Range	±0.01 to ±25 m/s
Repeatability	0.15%
Volumetric flow	±1 to 3%
Flow Velocity	±0.5%
Temperature range	-30°C to +200°C

Figure 3.10 Ultrasonic Flowmeter Sensor

3.4 CCTV Camera

CCTV networks may be used for a number of different purposes outside just detecting and deterring criminal behaviour and recording traffic violations. "Closed-circuit" television is only broadcast to a select group of monitors, as opposed to "normal" television, which is aired to the broader public. This CCTV camera is also used by RTCS to monitor under the water.

Figure 3.11 CCTV Camera

3.5 SLS Machine Farsoon SS402P

The Farsoon 402P series of selective laser sintering systems gives rapid prototyping and additive manufacturing users state-of-the-art production capabilities. The 402P is an exceptionally productive and efficient solution thanks to high-performance imaging, multi-zone heating systems, thermal stability advances, bi-directional single-source feed system,

and replaceable powder cylinders. Farsoon is the only selective sintering company with a single factory that oversees all areas of software, equipment, and material development. Customers benefit from one of the world's quickest, most thermally stable, and material-efficient additive manufacturing technologies, which has a low cost of ownership. The SLS 3D printer employs a laser as an energy source to melt powdered plastic material and fuse it together into a 3D manufactured item. This method is part of Laser Powder Bed Fusion (LPBF), one of the most advanced and dependable additive manufacturing 3D printing processes.

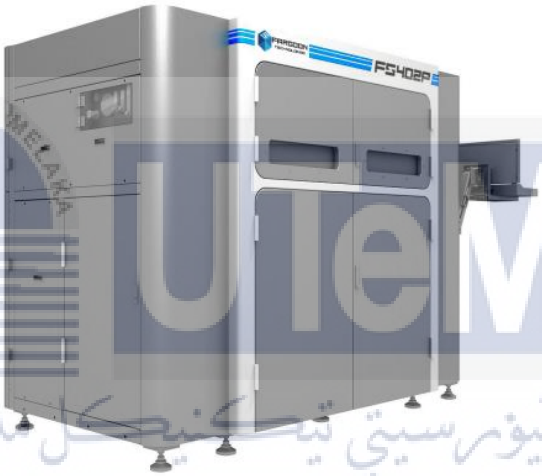


Figure 3.12 SLS Machine Farsoon SS402P

3.5.1 Sintering Process

The sintering process flow for the Farsoon SS402P machine is depicted in Figure 3.4.1, which includes pre-processing, SLS 3D printing, and post-processing stages. There are four processes in the pre-processing stage: measuring the weight of the material, calculating the height defined by Farsoon SLS software, and using the Farsoon AllstarTM open platform interface. With a feeder chamber dimension of 400mm x 400mm x 450mm, the weight required to fill the FS 3200PA powder is around 60kg powder. The powder will then be placed in a mixer machine to ensure that it is thoroughly mixed before being collected

and fed to the SLS machine's feeding chamber. The pieces are sintered using a 70-watt CO2 laser in the second stage of the printing/sintering process. Following the sintering process, the build chamber is drawn out of the sintering machine, and the pieces, along with the powder cake, are pushed out of the build chamber towards the acrylic enclosure by an actuator underneath the build chamber, as shown in Figure 14. Before being recycled for the next sintering operation, the powder cake is taken to a powder cleaning machine to remove any non-sintered powder. Then, using a removal tool such as a brush, remove all the components that still have a large powder cake attached. Finally, in addition to employing practical tools to remove powder from components, sand blasting pressure can eliminate any extra powder cake that remains on the components, making them cleaner than before.

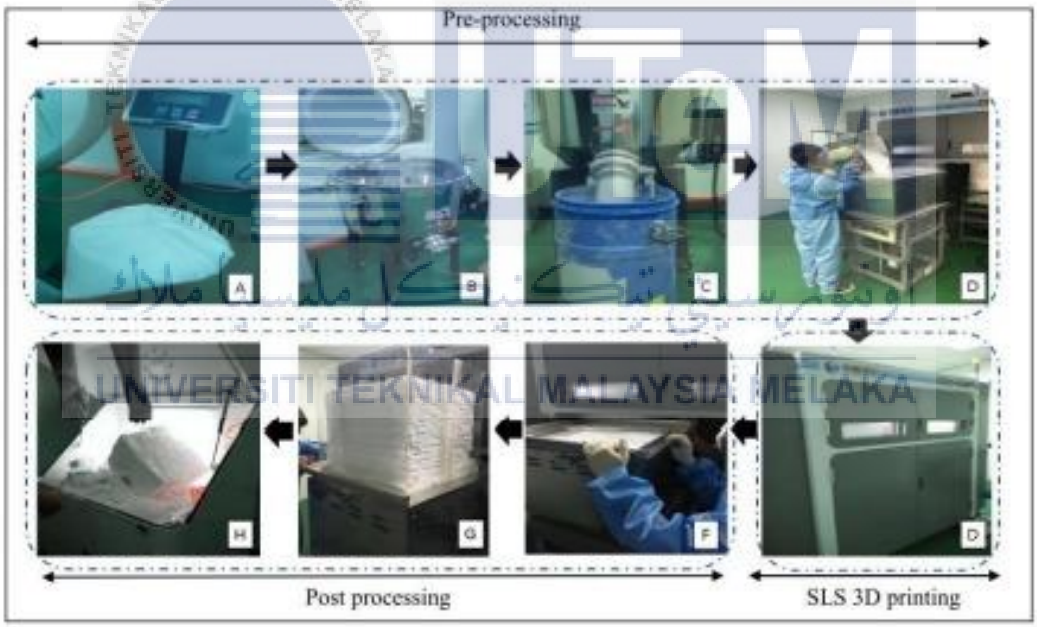


Figure 3.13 Pre Processing

Figure 3.14 Sintering process

3.6 Structure Design

Figure 3.15 shown HydroQS V3 that is the sensor body part for RTCS. It equipped with a monitoring camera that can be monitored directly from a mobile phone or the main control room.

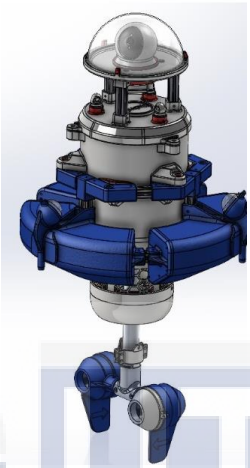


Figure 3.15 HydroQS V3

3.7 Monitor software

To monitor and collect all the data from sensor that been install to RTCS, it will use Home Assistant app that been connected to all the sensor. Figure 3.16 shown Home Assistant app icon meanwhile Figure 3.17 shown Home Assistant home screen that shown all the data that been captured.

Figure 3.16 Home Assistant app icon

Figure 3.17 Home Assistant home screen

3.8 Statistical Analysis

Collecting and analyzing data to look for patterns and trends is the process of statistical analysis. It is a technique for using numerical analysis to eliminate bias from data analysis. This method aids in the planning of surveys and studies as well as the collecting of data for research interpretation. By identifying common patterns and trends with the use of statistical analysis, a scientific technique, enormous volumes of data may be gathered, analyzed, and turned into informative information. Simply defined, statistical analysis is a data analysis method that aids in deriving meaningful conclusions from unstructured and raw data. Analysis of variance (ANOVA) has been used to analyze the data.

3.8.1 Analysis of Variance (ANOVA)

The statistical method known as Analysis of Variance is used to examine the variations in the means (or averages) of several groups (ANOVA). It is used in a variety of situations to discover whether there are any differences between the means of various groups. The outcome of the ANOVA is the "F statistic". With the use of this ratio, which distinguishes between within-group and inter-group variance, it is able to calculate whether the null hypothesis is accepted or rejected and decide if a figure represents the outcome. If there is a significant difference between the groups, the F-ratio will be larger, rejecting the null hypothesis.

There are two types of ANOVA:

- One-way ANOVA
- Two-way ANOVA

3.8.1.1 One-way ANOVA

The one-way analysis of variance is also known as the basic ANOVA or the single-factor ANOVA. As its name suggests, the one-way ANOVA is ideal for studies with a single independent variable (factor) with two or more levels. For instance, the month of the year with the most flowers in the garden may be a dependent variable. There will be twelve layers. The assumptions made by a one-way ANOVA are as follows:

- Independence: For a single observation, the value of the dependent variable is independent of the value of any additional observations.
- Normalcy: The dependent variable's value is distributed regularly.
- Variance: Comparable variances exist among other experimental groups.
- Continuous: The dependent variable may be measured on a scale with several divisions and is continuous.

3.8.1.2 Two-way ANOVA

If there are two or more independent variables, a full factorial ANOVA is employed. There might be several levels in each of these parts. For usage with full-factorial ANOVA, only experiments that employ all conceivable combinations of variables and their values are permitted. This time of year, there may be a peak in both the number of garden blossoms and the number of daylight hours. The independent vs. independent variable and whether the two variables interact are analyzed in this two-way ANOVA. The two-way ANOVA assumes:

- Continuous: The dependent variable must be continuous, just like in a one-way ANOVA.
- Independence: There is no crossover between any two samples, making each one independent.
- Variance: The data's variability is the same for each group.
- Normalcy: The samples are typical of the general population.
- Categories: The independent variables have to be divided into distinct classes or groups.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter present test, results and analysis of sensor durability of RTCS based on real time collection. The sensors that were used to get the data are Analog TDS Sensor, Temperature Sensor, Analog Dissolved Oxygen Sensor, Analog pH sensor, Turbidity Sensor, and Weight 50KG Sensor.

4.2 Pre-Testing Device

In order to avoid any issues during the field test, we do pre-testing. We pre-test our products using floating test and leakage tests. In order to avoid any issues damaging the motherboard of the sensor, the test have been tested carefully.

4.2.1 Floating Test

Before placing all the sensors into the body part, floating test is a must so that it can prevent from any damage to the sensors if HydroQS lost its balance or it sinking due to heavy a load.

4.2.1.1 Unbalance Buoys

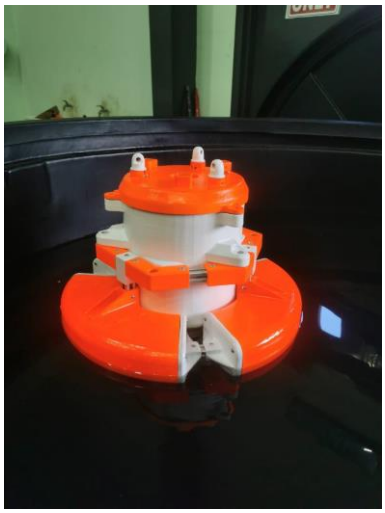


Figure 4.1 Unbalance Buoys

The first design of HydroQS only have 3 buoys. After put some force on the body part, it lost balance and overturned. It seems that the buoys cannot withstand heavy loads and easy to overturned. The cause of it is the area of the buoys are small and it may easy to overturned. Besides that, the buoys is a bit small and when it less in quantity it cannot withstand any heavy loads. A bigger wave also can overturned the HydroQS as it will lost its balance and unstable.

4.2.1.2 Balance Buoys

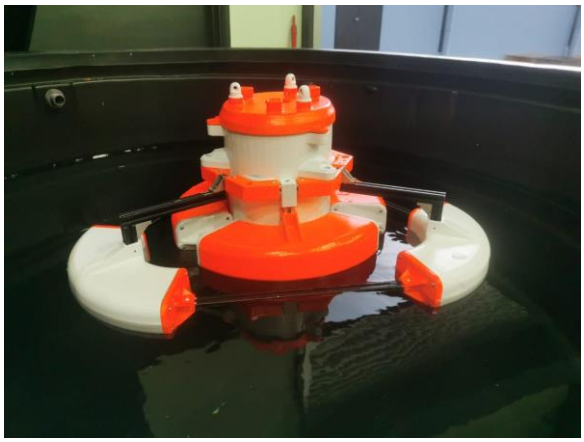


Figure 4.2 Balance Buoys

The improvement that were made is adding 3 more buoys. After adding 3 more buoys, the HydroQS seem more balance than before. The extra buoys help the HydroQS to be more balance and stable so it is hard to overturned eventhough the wave are a bit stronger. When some force were put ont the body parts, it is hard to overturned and do not lost it balance.

4.2.2 Leakage Test

To ensure there are no problems in the future, the body component must undergo a leak test prior to field testing. If there is any bodily leakage, the sensor may experience issues, and if the motherboard of the sensor comes into contact with water, the sensor will be damaged.

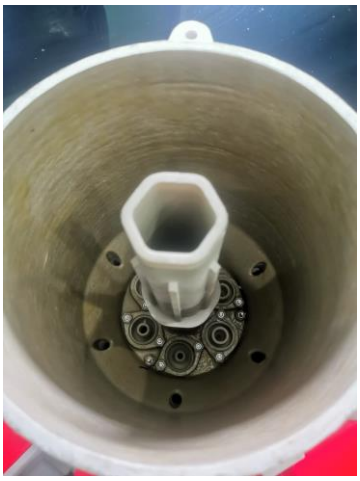


Figure 4.3 Leaking Body Part

4.2.2.1 Leakage Prevention

Figure 4.4 Protective Coating 901 1K Alkyd Finish

One of the thing that been used to prevent from leaking is using Protective Coating 901 1K Alkyd Finish. Protective Coating 901 1K Alkyd Finish is a clear, high-gloss oil-based alkyd finish that may be used inside or outside. It preserves the painted surfaces because to its great levelling and strong penetration into painted substrate. It has good clarity, emphasising the exquisite colour of the background. It also prevent water from penetrating the part that have been coated with it.

Figure 4.5 KK233 Enhanced Interface Emulsion

Besides that, to prevent from leaking, KK233 Enhanced Interface Emulsion is been used as second layer after Protective Coating 901 1K Alkyd Finish. The acrylic resin polymer is used in the formulation of KK233 Enhanced Interface Emulsion. It adheres well and penetrates deeply. A versatile product is KK233. It may be used as an adhesive, primer, water-based paint additive, cement mixture, and many other things.

Figure 4.6 Waterproof silicone sealants

The third layer for coating is water silicone waterproofing. Waterproof silicone sealants do available. They are frequently utilised for projects that involve submerged areas of water, partially submerged aquatic environments, and other projects that are exposed to the elements. The silicone is the best thing to prevent water leaking in the body part. It do not absorb water and seal the body part well.

Figure 4.7 O-ring

Beside coating, we used O-ring or rubber sealing ring at the sensors cap to seal the cap tightly so there is no water can escape through it. As a sealing device, O-rings' primary function is to stop fluid or air from escaping. The ring takes up the clearance when it is pressed between two surfaces, stopping any fluid or air from escaping.

4.3 Pre-tested Process

Using water samples from the lake on the UTeM main campus, the pre-tested results were collected in a lab. Some sensor data were acquired from a water sample, and weight sensor data were based on assumptions as trash had not yet been collected.

Figure 4.8 Water Sample Collecting

4.3.1 Pre-tested Data

Table 4.1 Pre-Tested Data

No	Sensor	Data		
1	Analog TDS Sensor			
2	Temperature Sensor			
3	Analog Dissolved Oxygen Sensor			
4	Analog pH sensor			
5	Turbidity Sensor			
6	Weight 50KG Sensor	17kg (1hours)	28 kg (2hours)	40 kg (3hours)

4.3.2 Discussion

Table 4.1 shown the pre-tested data that been tested before go to field test. These data were taken for a certain time so that it will get an accurate data and as for weight sensor, it shows that the amount of trash increase within time taken. As for weight sensor, we just assume the data from previous research data . The assume data were taken by hours. Every one hours, the weight of the trash will increase. although it tested every week and the data is not constant, the amount of trash are always in the same range. Other sensor that been used to take data is for water quality data. It shown all water quality parameters such as turbidity, pH, temperature, Dissolved oxygen and lastly TDS. The data taken in lab using water sample from UteM's lake.

4.4 Field Test

Figure 4.9 Field Test

The data were collected throughout the course of one day at three separate times near the lake on the UTeM main campus. The data were collected three times: once in the morning, once at midday, and once in the evening. Due of limited power supply and Wi-Fi connectivity, the data were collected for around 30 minutes.

4.5 Real Time Data

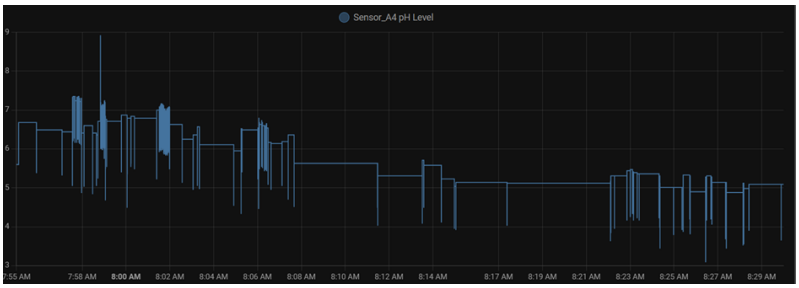
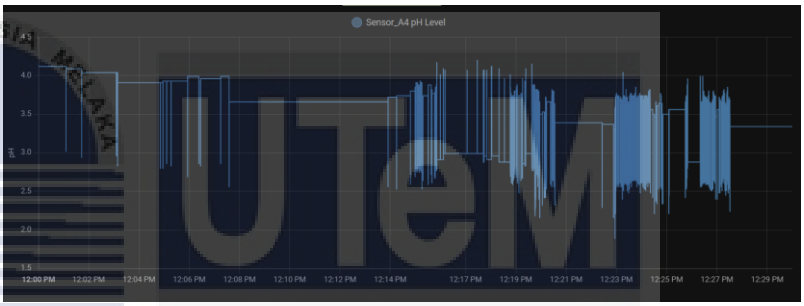
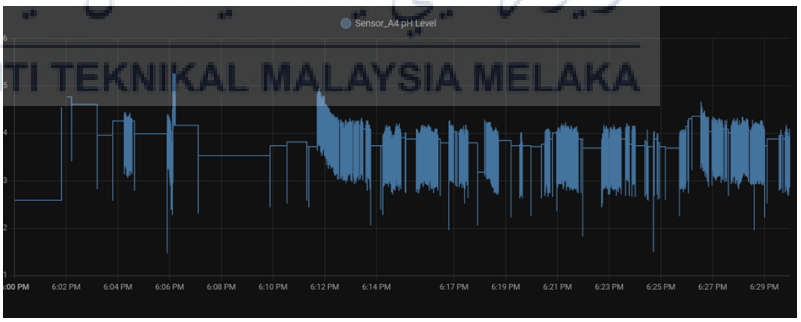
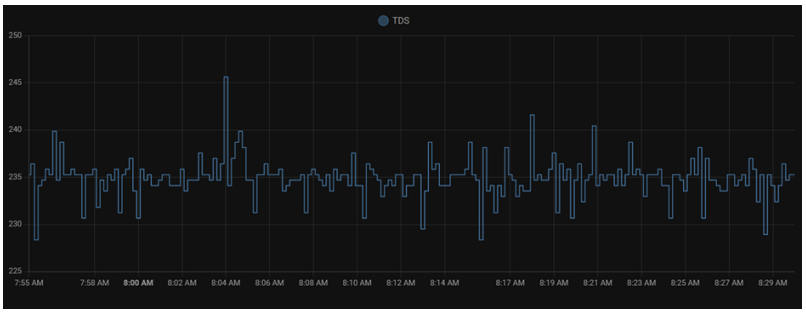
Table 4.2 Results Data

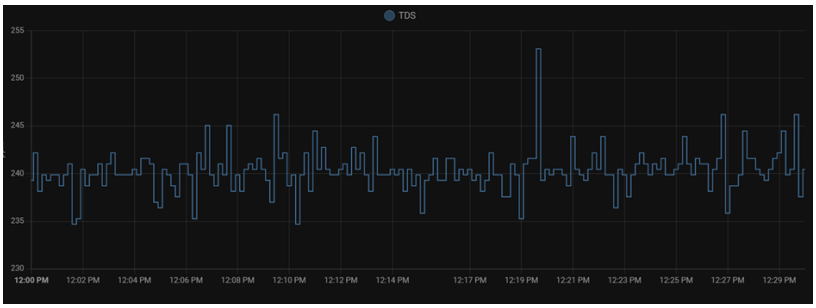
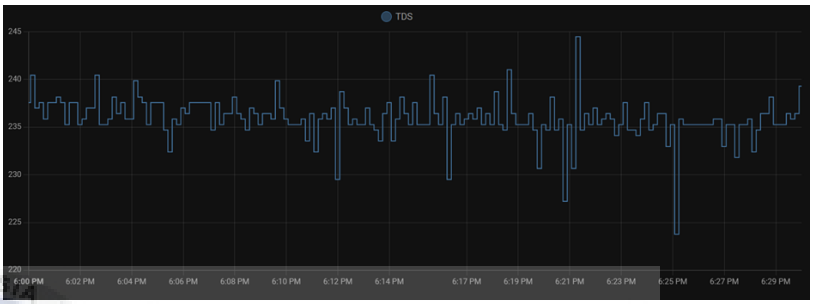
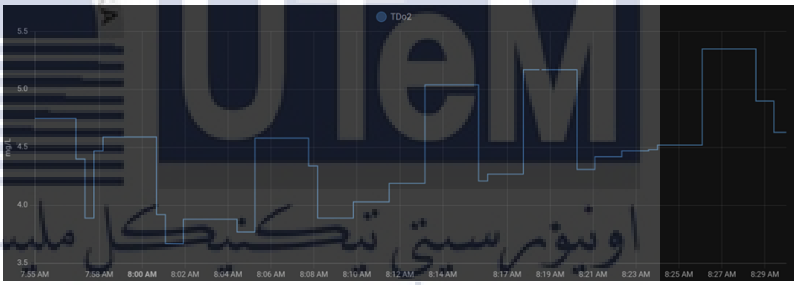
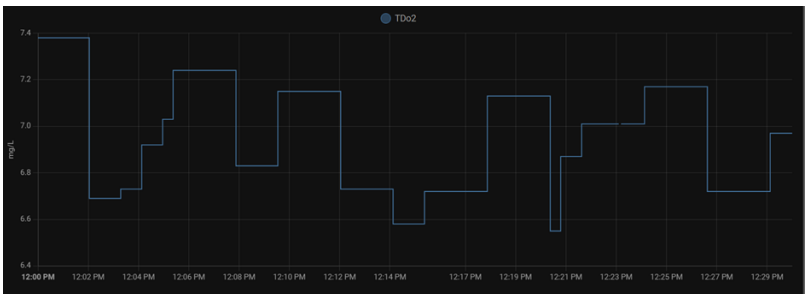
Time	start	end	pH	DO (mg/L)	TDS (mg/L)	Turbidity(NTU)	Temperature (°C)
Morning	8.00 am	8.02 am	6.68	4.75	246.78	3.22	26.8
	8.02 am	8.04 am	6.49	4.4	244.48	3.36	26.3
	8.04 am	8.06 am	6.44	4.59	245.7	3.45	24.7
	8.06 am	8.08 am	7.24	3.92	244.87	3.39	24.9
	8.08 am	8.10 am	7.3	3.77	246.8	3.38	23.8
	8.10 am	8.12 am	7.22	4.58	246.58	3.35	23.5
	8.12 am	8.14 am	6.71	3.89	244.76	3.39	24.6
	8.14 am	8.16 am	6.84	4.19	244.57	3.37	23
	8.16 am	8.18 am	6.71	5.04	245.98	3.32	24.7
	8.18 am	8.20 am	6.87	4.21	245.76	3.34	24.4
	8.20 am	8.22 am	6.84	5.17	246.76	3.39	24.3
	8.22 am	8.24 am	7	4.42	246.98	3.32	24.7
	8.24 am	8.26 am	6.95	4.52	247.87	3.35	23.8
	8.26 am	8.28 am	6.57	5.35	247.54	3.37	23.4
	8.28 am	8.30 am	6.54	4.9	244.87	3.36	24.6
Noon	12.00 pm	12.02 pm	6.58	7.38	244.98	3.39	25.7
	12.02 pm	12.04 pm	6.6	6.69	244.76	3.35	25.5
	12.04 pm	12.06 pm	6.78	6.92	243.97	3.36	25.9
	12.06 pm	12.08 pm	6.57	7.15	245.87	3.34	25.6
	12.08 pm	12.10 pm	7.01	6.73	245.78	3.37	25
	12.10 pm	12.12 pm	7.35	6.58	244.76	3.31	26.1
	12.12 pm	12.14 pm	7.89	7.13	244.56	3.32	26.4

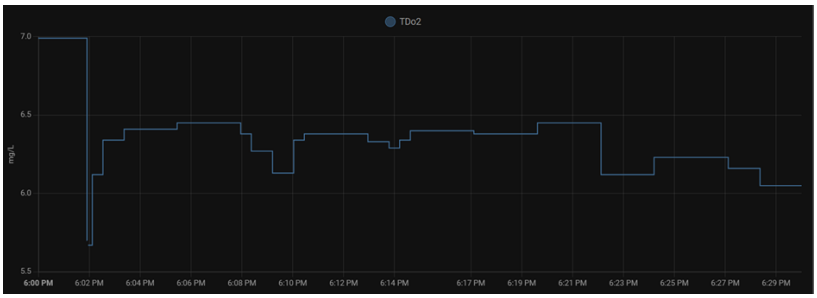
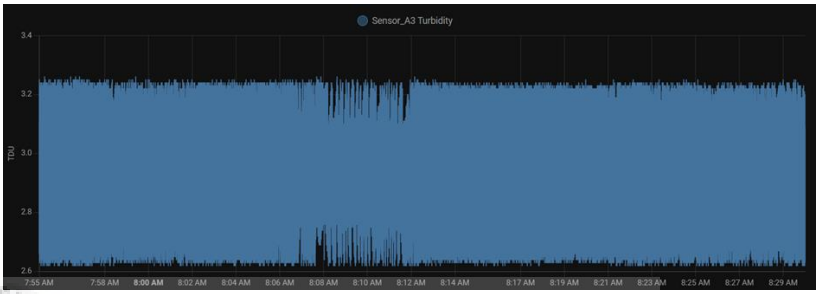
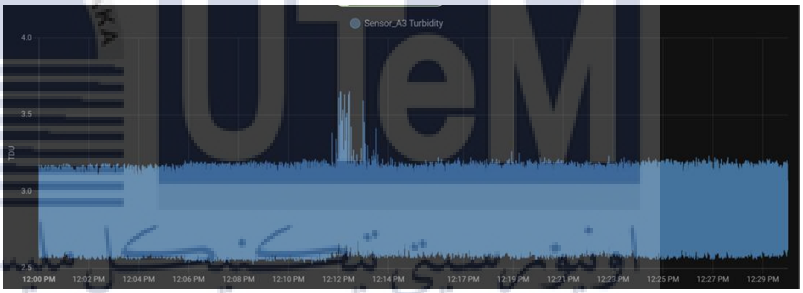
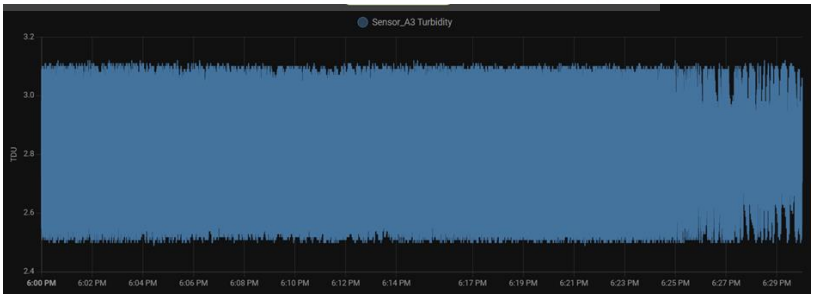
	12.14 pm	12.16 pm	7.9	6.55	244.98	3.38	25.4
	12.16 pm	12.18 pm	7.95	6.87	244.67	3.35	25.9
	12.18 pm	12.20 pm	6.69	7.01	246.7	3.37	25.7
	12.20 pm	12.22 pm	7	7.17	246.3	3.38	25.8
	12.22 pm	12.24 pm	7.2	6.72	243.65	3.34	25.6
	12.24 pm	12.26 pm	7.23	6.72	244.65	3.35	26.3
	12.26 pm	12.28 pm	8.01	6.97	244.93	3.33	26.8
	12.28 pm	12.30 pm	8.21	6.97	244.56	3.32	26.3
Evening	6.00 pm	6.02 pm	6.68	6.99	240.76	3.37	25.3
	6.02 pm	6.04 pm	6.98	6.12	246.27	3.35	25.6
	6.04 pm	6.06 pm	6.79	6.45	246.56	3.39	24.8
	6.06 pm	6.08 pm	6.99	6.38	244.3	3.32	24.7
	6.08 pm	6.10 pm	7.01	6.27	244.73	3.33	24.5
	6.10 pm	6.12 pm	7.23	6.13	244.98	3.39	24.9
	6.12 pm	6.14 pm	7.12	6.34	244.48	3.36	24.3
	6.14 pm	6.16 pm	8.02	6.33	244.97	3.35	24.7
	6.16 pm	6.18 pm	8.6	6.29	245.98	3.34	24.5
	6.18 pm	6.20 pm	7.2	6.34	245.75	3.39	24.8
	6.20 pm	6.22 pm	7.03	6.4	245.87	3.34	24.9
	6.22 pm	6.24 pm	6.98	6.38	246.98	3.3	24.7
	6.24 pm	6.26 pm	6.87	6.45	247.87	3.38	24.3
	6.26 pm	6.28 pm	6.85	6.12	245.98	3.39	24.4
	6.28 pm	6.30 pm	6.58	6.23	245.97	3.34	24.1

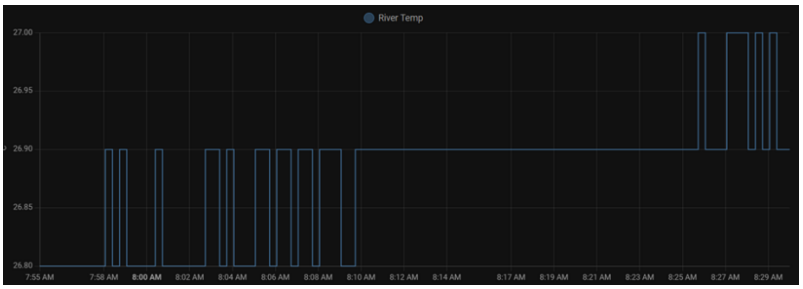
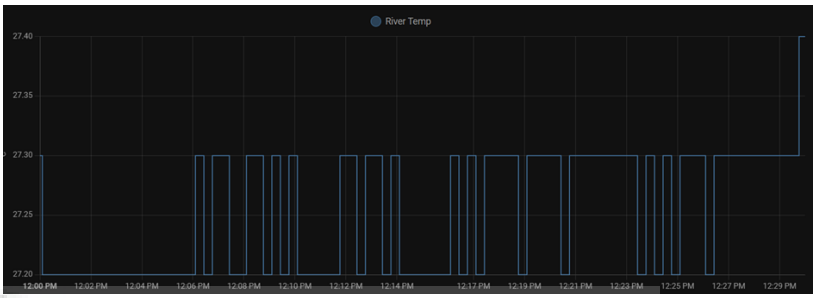
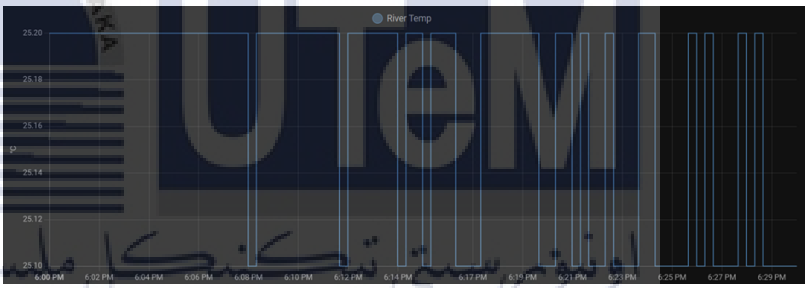
4.6 Graph

Table 4.3 Sensor Analysis Graph

Sensors	Time	Graph
pH	Morning	
	Noon	
	Evening	
TDS	Morning	

	Noon	
	Evening	
DO	Morning	
	Noon	

	Evening	
Turbidity	Morning	
	Noon	
	Evening	

Temperature	Morning	
	Noon	
	Evening	

The graph was obtained from the Home Assistant app as it can display a graph for each installed sensor in HydroQS V3. The data for each graph were collected in the morning, noon, and evening. Every sensor displayed its unique patterns, and the data were collected at the period of peak activity for each.

4.7 Statistical Analysis (ANOVA)

ANOVA procedures are the statistical analysis technique that has been employed. The statistical formula ANOVA is used to investigate differences between the means (or averages) of different groups. It may be applied in a number of circumstances to look for variations in group means.

Rules of ANOVA:
If $\alpha > p - value$;
The H_o can be rejected and H_a can be accepted.

If $\alpha < p - value$;
The H_o cannot be rejected. Just follow the H_o statement

4.7.1.1 pH sensors

Table 4.4 pH Result

Sensors	Morning	Noon	Evening
pH	6.68	6.58	6.68
	6.49	6.6	6.98
	6.44	6.78	6.79
	7.24	6.57	6.99
	7.3	7.01	7.01
	7.22	7.35	7.23
	6.71	7.89	7.12
	6.84	7.9	8.02
	6.71	7.95	8.6
	6.87	6.69	7.2
	6.84	7	7.03
	7	7.2	6.98
	6.95	7.23	6.87
	6.57	8.01	6.85
	6.54	8.21	6.58

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Morning	15	102.4	6.826667	0.075481
Noon	15	108.97	7.264667	0.344241
Evening	15	106.93	7.128667	0.273112

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

Between Groups	1.50772	2	0.75386	3.264244	0.048118	3.219942
Within Groups	9.69968	42	0.230945			
Total	11.2074	44				

$$\alpha = 0.05$$
$$p - value = 0.048118$$

H_o = there is no significant difference for the TDS between morning, noon and evening
H_o = there is significant difference for the TDS between morning, noon and evening

Since $\alpha > p - value, H_o$ can be rejected, thus it can conclude difference for the pH between morning, noon and evening is significant.

4.7.1.2 TDS sensors

Table 4.5 TDS Results

Sensor	Morning	Noon	Evening
TDS	246.78	244.98	240.76
	244.48	244.76	246.27
	245.7	243.97	246.56
	244.87	245.87	244.3
	246.8	245.78	244.73
	246.58	244.76	244.98
	244.76	244.56	244.48
	244.57	244.98	244.97
	245.98	244.67	245.98
	245.76	246.7	245.75
	246.76	246.3	245.87
	246.98	243.65	246.98
	247.87	244.65	247.87
	247.54	244.93	245.98
	244.87	244.56	245.97

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Morning	15	3690.3	246.02	1.255714
Noon	15	3675.12	245.008	0.683374
Evening	15	3681.45	245.43	2.601686

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

Between Groups	7.75164	2	3.87582	2.560678	0.089261	3.219942
Within Groups	63.57084	42	1.513591			
Total	71.32248	44				

$$\alpha = 0.05$$
$$p - value = 0.089261$$

H_o = there is no significant difference for the TDS between morning, noon and evening
H_o = there is significant difference for the TDS between morning, noon and evening

Since $\alpha < p - value, H_o$ cannot be rejected, thus it can conclude difference for the pH between morning, noon and evening is no significant.

4.7.1.3 DO sensors

Table 4.6 DO Results

Sensors	Morning	Noon	Evening
DO	4.75	7.38	6.99
	4.4	6.69	6.12
	4.59	6.92	6.45
	3.92	7.15	6.38
	3.77	6.73	6.27
	4.58	6.58	6.13
	3.89	7.13	6.34
	4.19	6.55	6.33
	5.04	6.87	6.29
	4.21	7.01	6.34
	5.17	7.17	6.4
	4.42	6.72	6.38
	4.52	6.72	6.45
	5.35	6.97	6.12
	4.9	6.97	6.23

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Morning	15	67.7	4.513333	0.223981
Noon	15	103.56	6.904	0.057454
Evening	15	95.22	6.348	0.043789

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	46.95212	2	23.47606	216.553	7.51E-23	3.219942
Within Groups	4.553133	42	0.108408			
Total	51.50526	44				

$$\alpha = 0.05$$
$$p - value = 7.51E - 23$$

H_o = there is no significant difference for the TDS between morning, noon and evening
H_o = there is significant difference for the TDS between morning, noon and evening

Since $\alpha > p - value, H_o$ can be rejected, thus it can conclude difference for the pH between morning, noon and evening is significant.

4.7.1.4 Turbidity Sensor

Table 4.7 Turbidity Results

Sensor	Morning	Noon	Evening
Turbidity	3.22	3.39	3.37
	3.36	3.35	3.35
	3.45	3.36	3.39
	3.39	3.34	3.32
	3.38	3.37	3.33
	3.35	3.31	3.39
	3.39	3.32	3.36
	3.37	3.38	3.35
	3.32	3.35	3.34
	3.34	3.37	3.39
	3.39	3.38	3.34
	3.32	3.34	3.3
	3.35	3.35	3.38
	3.37	3.33	3.39
	3.36	3.32	3.34

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Morning	15	50.36	3.357333	0.002478
Noon	15	50.26	3.350667	0.000592
Evening	15	50.34	3.356	0.000811

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000373	2	0.000187	0.144259	0.866091	3.219942
Within Groups	0.054347	42	0.001294			
Total	0.05472	44				

$$\alpha = 0.05$$
$$p - value = 0.866091$$

H_o = there is no significant difference for the TDS between morning, noon and evening
H_o = there is significant difference for the TDS between morning, noon and evening

Since $\alpha < p - value, H_o$ cannot be rejected, thus it can conclude difference for the pH between morning, noon and evening is not significant.

4.7.1.5 Temperature Sensor

Table 4.8 Temperature Results

Sensor	Morning	Noon	Evening
Temperature	26.8	25.7	25.3
	26.3	25.5	25.6
	24.7	25.9	24.8
	24.9	25.6	24.7
	23.8	25	24.5
	23.5	26.1	24.9
	24.6	26.4	24.3
	23	25.4	24.7
	24.7	25.9	24.5
	24.4	25.7	24.8
	24.3	25.8	24.9
	24.7	25.6	24.7
	23.8	26.3	24.3
	23.4	26.8	24.4
	24.6	26.3	24.1

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Morning	15	367.5	24.5	1.022857
Noon	15	388	25.86667	0.206667
Evening	15	370.5	24.7	0.151429

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16.34444	2	8.172222	17.75345	2.58E-06	3.219942
Within Groups	19.33333	42	0.460317			
Total	35.67778	44				

$$\alpha = 0.05$$
$$p - value = 2.58E - 06$$

H_o = there is no significant difference for the TDS between morning, noon and evening
H_o = there is significant difference for the TDS between morning, noon and evening

Since $\alpha > p - value, H_o$ can be rejected, thus it can conclude difference for the pH between morning, noon and evening is significant.

4.8 Statistical Analysis Summary

Table 4.9 ANOVA Summary

Sensors	ANOVA Results
pH	Significant
TDS	Not Significant
DO	Significant
Turbidity	Not Significant
Temperature	Significant

Based on ANOVA analysis for all parameters, only pH, DO and Temperature sensors indicated a significant reading between when the data collected in different times. As temperature, the data were significant between when the data collected in different times because of in the morning, the temperature drop a bit and cold. In the afternoon and evening, the temperature rises and a bit hotter than in the morning.

Besides that, for TDS and Turbidity, the data were not significant because of the lake water is a still and does not flow. Therefore, the lake water is not too muddy and it causes the data taken to be unaffected and not significant

CHAPTER 5

5.1 Conclusion

As stated in the objective above, we succeed in creating sensor systems for RTCS. HydroQS V3 has the sensor system installed, and it is linked to RTCS. Although there is a small issue with the HydroQS V3's leak, it is still functional. The time it takes to collect the data is also constrained according to how slowly the process is progressing toward completion of the final result. The installation of the sensor had various problems, and it required several calibrations before the product could be finished. In conclusion, the data were taken 3 times for one day that is morning, noon and evening for about 30 minutes. In order to be able to discriminate between sensors that obtained significant data and non-significant data, the analysis was carried out using the ANOVA approach. Only the pH, DO, and temperature sensors showed a difference in readings between data taken at different times since it was cold and a little chilly in the morning. Since the lake's water remains calm and does not flow, the statistics for TDS and turbidity were unaffected and hence not significant.

5.2 Recommendation

For future improvements, these are the recommendation given:

- Use fiberglass and gelcoat to prevent leaks in HydroQS's body part.
- Once every two weeks, calibrate the sensor to ensure good operation and accurate results.
- Use stainless steel screws for long-lasting protection against corrosion.

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APPENDIX

APPENDIX 1 Gantt Chart