IOT-BASED DEVICE FOR REAL-TIME WATER QUALITY MONITORING SYSTEM

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This report is submitted in partial fulfillment of the requirements for the Bachelor of [Computer Science (Computer Networking)] with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I hereby declare that this project report entitled

IOT-BASED DEVICE FOR REAL-TIME WATER QUALITY MONITORING SYSTEM

is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT : ______________________________ Date : ________
(SYAHRIN FANDI BIN RAZALI)

I hereby declare that I have read this project report and found this project report is sufficient in term of the scope and quality for the award of Bachelor of [Computer Science (Computer Networking)] with Honours.

SUPERVISOR : ______________________________ Date : ________
(DR. NURUL AZMA BINTI ZAKARIA)

DECLARATION

DEDICATION

To my beloved parents for their care and support throughout my bachelor' degree and for words of encouragement which helped me complete my final task successfully. To my supervisor, evaluator and lecturer for molding me into a knowledgeable person. To my friend and course mates for sharing information and giving support throughout my education at university.

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Firtsly, I would like to take this opportunity to express my highest gratitude to my dearest supervisor Dr. Nurul Azma Binti Zakaria. Dr. Azma, thanks to your continuous guidance and advices throughout the whole process of this final year project. Furthermore, your patience and understanding had helped me through all problems that I faced during the progress of doing this project.

Next, I would like to thanks to my evaluator for this project, Ts. Dr. Robiah Binti Yusof, for your opinions towards the weakness in my project and guidance for me to improve my project.

Lastly, I would like thanks to my parents and friends for their understanding and give fully support for me to complete the final year project report.

ABSTRACT

Over the past few months, waters in and around Peninsular Malaysia have gradually succumbed to a fair degree of pollution. Chemical waste and oil spills are the major, primary forms of water pollution threatening Malaysia’s waterways. For example, an article published in the New Straits Times on 14 March 2019 reported a total of 2.43 tonnes of chemical wastes were collected from Sungai Kim Kim in Pasir Gudang during the cleaning process and caused hundreds of people got sickened by toxic fumes. The most common method to detect these parameters is to collect samples manually and then send them to laboratory for detecting and analyzing. This method wastes too much manpower and material resource, and has the limitations of the samples collecting, long-time analyzing, the aging of demonstration equipment and other issues. IOT based Water Quality Monitoring is a device that helps to define the water quality parameter such as pH value, turbidity level, dissolved oxygen, and temperature of the water. The device will monitor and measure the water quality of water bodies around Malaysia. The system is designed to help prevent the degradation of lake and rivers to continue deteriorate without monitoring or prevention. It also helps user to understand the suitable conditions of water bodies in Malaysia. The device will have equipped with multiple analog sensor that connect to Arduino UNO. An application called IFTTT also will be used to personalize the system with a notification or alert system by using push notification services to their smartphone. This will help the user to act wisely and to continue monitor with precaution. The data collected by the sensors will be displayed into application called Blynk. Blynk platform helps to connect IoT environments to our smartphone. As result, we will gather all the samples to make a conclusion of suitable for water supply with a conventional treatment required, suitable for sensitive aquatic species and suitable for recreational use with body contact.

ABSTRAK

Sepanjang beberapa bulan yang lepas, perairan di sekitar Semenanjung Malaysia secara beransur-ansur menimpa pencemaran yang adil. Sisa kimia dan tumpahan minyak adalah bentuk utama pencemaran air yang mengancam saluran air Malaysia. Sebagai contoh, sebuah artikel yang diterbitkan di New Straits Times pada 14 Mac 2019 melaporkan sejumlah 2.43 tan bahan buangan kimia telah dikumpulkan dari Sungai Kim Kim di Pasir Gudang semasa proses pembersihan dan menyebabkan beratus-ratus orang mendapat sakit asap beracun. Kaedah yang paling biasa untuk mengesan parameter ini adalah untuk mengumpul sampel secara manual dan kemudian menghantarnya ke makmal untuk mengesan dan menganalisis. Kaedah ini membuang terlalu banyak tenaga kerja dan sumber bahan, dan mempunyai batasan pengumpulan sampel, menganalisis jangka panjang, penuaan peralatan demonstrasi dan isu-isu lain. Pemantauan Kualiti Air berasaskan IOT adalah peranti yang membantu menentukan paras kualiti air seperti nilai pH, tahap kekeruhan, oksigen terlarut, dan suhu air. Peranti ini akan memantau dan mengukur kualiti air di seluruh Malaysia. Sistem ini direka untuk membantu mengelakkan kemusnahan tasik dan sungai untuk terus merosot tanpa pemantauan atau pencegahan. Ia juga membantu pengguna untuk memahami keadaan air yang sesuai di Malaysia. Peranti ini akan dilengkapi dengan pelbagai sensor analog yang menyambung ke Arduino UNO. Aplikasi yang dipanggil IFTTT juga akan digunakan untuk memperibadikan sistem dengan pemberitahuan atau sistem amaran dengan menggunakan perkhidmatan notifikasi push ke telefon pintar mereka. Ini akan membantu pengguna bertindak dengan bijak dan terus memantau dengan berhati-hati. Data yang dikumpul oleh sensor akan dipaparkan kepada aplikasi yang dipanggil Blynk. Platform Blynk membantu menyambungkan persekitaran IoT ke telefon pintar. Justeru itu, pengguna akan dapat mengumpulkan semua sampel untuk membuat kesimpulan yang sesuai untuk bekalan air dengan rawatan konvensional yang diperlukan, sesuai untuk spesies akuatik yang sensitif dan sesuai untuk kegunaan rekreasi yang bersentuhan dengan badan.

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LIST OF ABBREVIATIONS

DOE	**-**	**Department of Environment**
WQI	**-**	**Water Quality Index**
NWQS	**-**	**National Quality Standards for Malaysia**
IoT	**-**	**Internet of Things**
ORP	**-**	**Oxidation and Reduction Potential**
SDLC	**-**	**Software Development Life Cycle**
IDE	**-**	**Integrated Development Environment**
DO	**-**	**Dissolved Oxygen**
mm	**-**	**millimeter**
TDS	**-**	**Total Dissolved Solids**

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Freshwater from lakes, rivers and other water bodies are essential to agriculture, industry and it is crucial in maintaining the human existence. Humans now take granted of the clean water they use every day and not think about the water quality that may affect their life. The quality of the water bodies can be affected by various types of human activities or natural occurrences. The effects of these human or natural activities are far-ranging and widespread in which they can disrupt ecosystem or even restrict the water usage.

Quality and pollution control of rivers must be critically discussed because 98 percent of the water that we use comes from river water. Agricultural industries in the country use about 70 percent of the water supplies. As the river's pollution raises, concentration of the current pollutants also raises. Therefore, the health of the rivers and lakes and the ecological environment around the water bodies also degrade. Further, it can affect the lives and habitat of animals or aquatic lives and also for humans to have regular recreational activities. The Department of Environment (DOE) of Malaysia (Quality of Water Resources in Malaysia 2015) has been using standards such as Water Quality Index (WQI) and National Quality Standards for Malaysia (NWQS) (Quality of Water Resources in Malaysia 2015) (Drahansky et al., 2016) to assess the status of quality of the rivers and lakes. The standard WQI were introduced by the DOE has been practiced in Malaysia for over 25 years. It has acts as the basic evaluation of water quality. Meanwhile, the standard NWQS shows the helpful usage of the river water based on the WQI. In 2012, nine rivers within the Klang River Basin under River of Life Project were added to the national river water quality monitoring programme. The rivers quality was evaluated based on 5083 were taken as samples taken from 473 rivers. Out of 473 rivers monitored, 278 (59 percent) were found to be clean, 161 (34 percent) slightly polluted and 34 (7 percent) polluted (Drahansky et al., 2016).

Meanwhile, lakes in Malaysia whether it is artificial or natural also have numerous purposes. About 90% of the country’s water usage comes from lakes and reservoirs. Lakes and reservoirs main functions are they serves as main supply of waterpower generation (hydroelectric), industrial, agriculture, domestic and navigation. Lakes also are the habitat of various species of aquatic lives and also the main sources for freshwater fish farm industry for example in Bukit Merah Lake is the consider the home of an exotic species of fish called the Malayan Gold Arowana, Scleropages formosus and it is estimated the fish could cost about USD15,000 – USD 25,000 per full grown fish (Farm, A, Abustan, & Mahyun, 2013). The quality of the lakes is influenced by external inputs whether it is organic or inorganic pollutants. These pollutants usually include runoff water or wastewater that comes from storm water, agricultural, septic tank overflow and construction sites and this can lead to eutrophication. There is no specific index or standards for lakes and reservoirs water quality in Malaysia as for the year 2014. Since lakes are associated with river also, the quality standards and classification are similar to the river’s quality standards. Usually, lake water quality is analyze based on the DOE’s WQI regulation. In Malaysia, lakes and reservoirs are managed by different agencies with different opinions and agendas (Drahansky et al., 2016).

Water pollution can come from a variety of sources. Pollution can enter water directly, through both legal and illegal discharges from factories, for example, or inadequate water treatment plants. Spills and leaks from oil pipelines or hydraulic fracturing (fracking) operations can degrade water supplies. Wind, storms, and littering especially of plastic waste can also send debris into waterways (Cristina Nunez 2010). In order to monitor and control the water bodies is by water quality monitoring. Regular monitoring of the water bodies is very important part in pinpoint the current problems or any issues that may surface in the future. This project presents a device to monitor the river and lakes water quality. This platform is put on water surface whether in rivers or lakes and left to collect data from sensors of temperature, pH, DO, and turbidity of the water bodies. All the data from the sensors are monitored from a remote location. For this project, the Arduino UNO is used as a controller that record all data and send it to a storage platform. Then, the data and analysis can be viewed by users in real-time using the internet.

This involves the Internet of Things (IoT) through numerous technology advances, society is moving towards an “always connected” paradigm. Since IoT now can helped the community through various platform, the project will integrate the elements into the device. Other than that, IoT allows objects or “things” to be sensed and controlled remotely across existing network infrastructure. The information sources and the humans are always connected to the internet. IoT technology is suitable for applied to environmental monitoring application.

1.2 Problem Statement (PS)

Over the past few months, waters in and around Peninsular Malaysia have gradually succumbed to a fair degree of pollution. Chemical waste and oil spills are the major, primary forms of water pollution threatening Malaysia’s waterways (Mohamed Farid Noh 2019). For example, an article published in the New Straits Times on 14 March 2019 reported a total of 2.43 tonnes of chemical wastes were collected from Sungai Kim Kim in Pasir Gudang during the cleaning process and caused hundreds of people got sickened by toxic fumes (Izlaily Hussein 2019). The most common method to detect these parameters is to collect samples manually and then send them to laboratory for detecting and analyzing. This method wastes too much manpower and material resource, and has the limitations of the samples collecting, long-time analyzing, the aging of demonstration equipment and other issues.

Table 1.1: Summary of Problem Statement

PS	Problem Statement
PS1	The existing method to detect test water quality is to collect samples manually and then send them to laboratory for detecting and analyzing and it wastes too much manpower and material resource.

1.3 Project Question (PQ)

There are few questions arise from the problem statement stated before. These questions must be asked to understand the problem statement and to determine the objective of this project. First question arise is to find out the conditions of the water quality of lakes and rivers to raise awareness to public to help preserve the quality of the water bodies. Besides that, this project is to find out the effective way to gather data on the water quality of the water bodies. This project is all about data gathering and this is why the question is important for the project to escalate smoothly.

Table 1.2: Project Questions

PS	PQ	Project Questions
PS1	PQ1	What are the parameters for water quality monitoring?
	PQ2	How to gather data effectively on the water quality of the water bodies?

1.4 Project Objective (PO)

- To study conditions of the water quality level of lakes and rivers by using real-time monitoring
    - To identify the key parameter used in water quality monitoring.
    - Identify the key factors of water quality monitoring data is used and how its collected.

- To develop a device that can detect the pH, dissolved oxygen, water level, turbidity and temperature of the water bodies.

    - The device must be able to detects certain parameter of water quality
    - Furthermore, the device also must be able to monitor data in a real-time manner.
    - The device could alert user if certain threshold surpassed.
    - To test the accuracy of the measurement, take by the sensors.

- To provide statistical information of lakes and rivers water quality using smartphone application.

    - Monitor the progress and measure the response time of the device
    - Able to access data and generate report remotely.

Table 1.3: Project Objectives

PS	**PQ**	**PO**	**Project Objective**
PS1	PQ1	PO1	To study conditions of the water quality of lakes and rivers by using real-time monitoring.
	PQ2	PO3	To develop a device that can detect the pH, dissolve oxygen, water level, turbidity and temperature of the water bodies.
			To provide statistical information of lakes and rivers water quality using smartphone application.

1.5 Project Scope

The scope of this project are going to be handles as follow:

- Focusing on the water bodies around Melaka

- Device consist a single board computer and sensor data is access by an application ‘Blynk’ using smartphone
    - Arduino UNO, pH, dissolved oxygen, water level, turbidity and temperature sensors
    - Blynk is an application or and IoT platform to connect your devices to the cloud, design apps to control them, and manage your data at scale.
- Focusing only on pH, dissolved oxygen, water level, turbidity and temperature of the lakes and rivers.
- Target user
    - Authority which involved in monitoring the water quality of lakes and rivers

1.6 Project Contribution

This research can benefit many people as where all aspects of life require clean water. Many departments of government can gain from this research in which they can use products to their benefit. The products can be used in many fields such as irrigation, drainage and even sanitation. Government bodies such Water Regulatory Body and Water Supply Body can benefit from this product greatly in which they can applied this product into their practice. Furthermore, the products also can be beneficial to homeowners which they can use the product themselves to check water quality in their home to ensure clean water for everyone.

The proposed project is set to help user identifies the water quality of rivers and lakes in area in a real-time manner by an application using smartphone without taking sample to a lab. The water quality includes the pH, dissolve oxygen, and turbidity of the water. The idea is to use sensors configured into the microcontroller and send data to an application on smartphone devices. The data is compiled into statistical and quantitative information. Data gathering is accessible remotely without having to manually retrieve data from the device.

Table 1.4: Project Contribution

<table>
<tr><td>PS</td><td>PQ</td><td>PO</td><td>PC</td><td>Project Contributions</td></tr>
<tr><td rowspan="3">PS1</td><td>PQ1</td><td>PO1</td><td>PC2</td><td>Proposed an analysis of suitable sensors for water level.</td></tr>
<tr><td rowspan="2">PQ2</td><td>PO2</td><td>PC2</td><td>Proposed a device to detect the water quality parameters (pH, dissolve oxygen, water level, turbidity and temperature)</td></tr>
<tr><td>PO3</td><td>PC3</td><td>Proposed a system that monitor the water quality in a real-time manner.</td></tr>
</table>

1.7 Research Significant

This project is aim to develop prototype which can help user identifies the water quality of rivers and lakes in area in a real-time manner by an application using smartphone without taking sample to a lab. The water quality includes the pH, dissolve oxygen, and turbidity of the water. The idea is to use sensors configured into the microcontroller and send data to an application on smartphone devices. The data is compiled into statistical and quantitative information. Data gathering is accessible remotely without having to manually retrieve data from the device.

1.8 Preliminary Analysis

This section explained about the comparison between water level sensor and ultrasonic sensor. Water level sensor is designed for water detection, which can be widely used in sensing the rainfall, water level, even the liquate leakage. Ultrasonic Sensor HC-SR04 is a sensor that using sound waves. It used to reflect sound wave principles. The ultrasonic sensors emitted sound waves and will reflected if there an object in front of it. The sensor will calculate the distance after it detect the waves. The application performance depends largely on the quality of sensor.

To select suitable sensor for the application, there are three main things need to be considered for selecting sensor which are:

- Accuracy

  Amount of variation in respect to an actual standard measurement. Specifications of measurement typically include the possibility of error because of gain and offset parameters.

- Sensitivity

  Is an actual value, the smallest absolute transition, which a sensor may detect

- Precision

  Measure a steady state signal many times. If the values are similar together, then the reliability or repeatability is high. In this situation. The principles must not only be divided into the true values. Take the average and the difference is between the proportions and the true value is precision (TechTip n.d)

These three main things will determine the accuracy of the result.

1.8.1 Comparative Analysis

This section compares two types of sensor that are using light waves and sound waves which are water level sensor and ultrasonic sensor.

1.8.2 Prototype Circuit Design

1.8.2.1 Water Level Sensor Circuit Design

Diagram below shows the water level sensor circuit design used to compare with ultrasonic sensor.

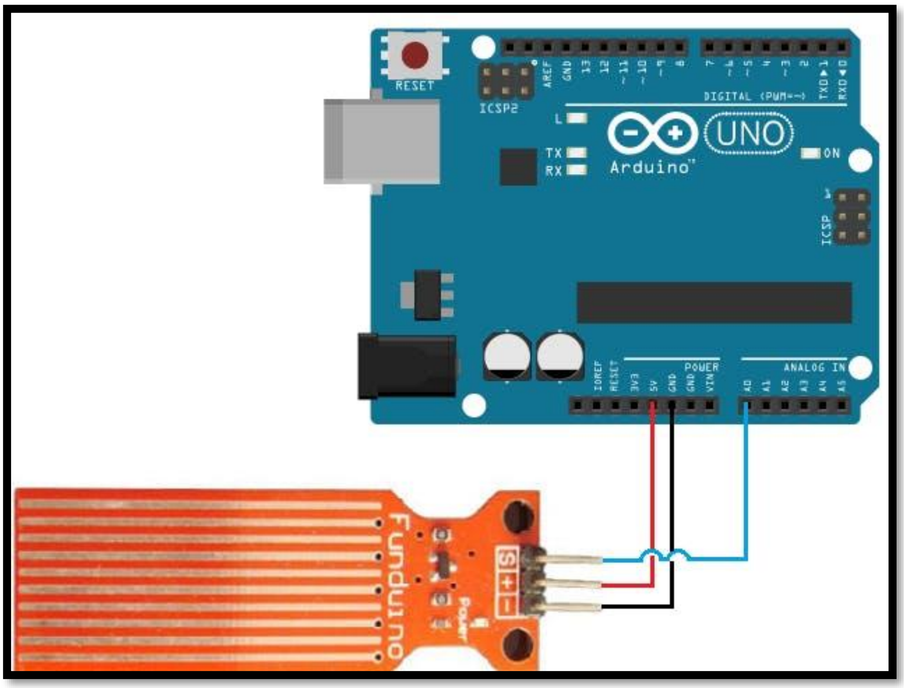

Figure 1.1: Water Level Sensor Circuit Design

1.8.2.2 Ultrasonic Sensor HC-SR04 Circuit Design

Diagram below shows the ultrasonic sensor HC-SR04

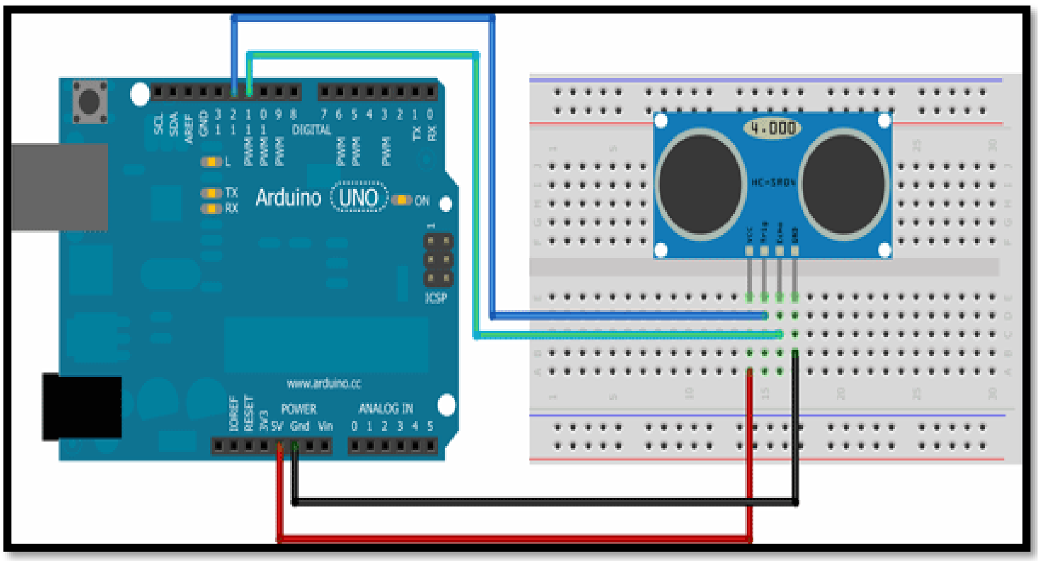

Figure 1.2: Ultrasonic Sensor HC-SR04 Circuit Design

1.8.3 Flow Chart of the Water Level Sensor and Ultrasonic Sensor

The figure 1.5 shows the flow chart of the water level sensor and ultrasonic sensor comparison. Firstly, the prototype starts by power on the Arduino by using laptop as the power source. The water level sensor will be detecting the present of the water and calculate the water level. The ultrasonic sensor will be detecting an object and estimate the distance. Then the implemented algorithm will be used to get the result of the distance between the sensors and object. The result will be display in serial monitor in Arduino IDE also in serial LCD. Then record the result from the display with manual data fixed measurement until 5cm of water and compare the data.

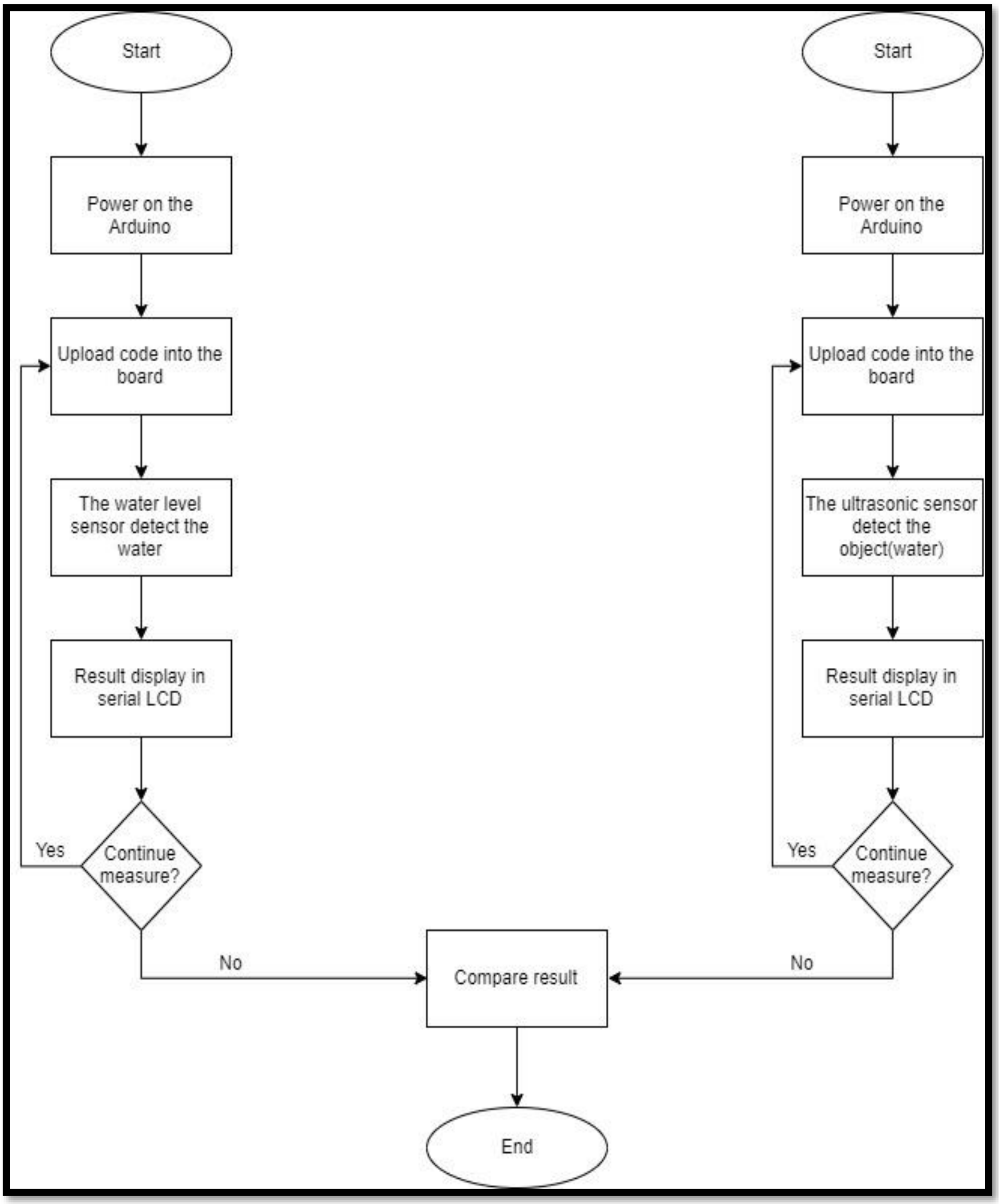

Figure 1.3: Flow Chart of the Water Level Sensor and Ultrasonic Sensor(HC-SR04)

1.8.4 Result Table

The data been collected after analysis have been made for result table

1.8.4.1 Water Level Sensor Result Table

The analysis consists of two readings. Fixed water level is 1 cm to 5 cm need to be changed accordingly.

Table 1.5: Water Level Sensor Data Reading Result for Indoor Environment

1st Data Reading		2nd Data Reading	
Manual (Fixed)	Output	**Manual (Fixed)**	Output
1.0 cm	215 mm	**1.0 cm**	217 mm
2.0 cm	231 mm	**2.0 cm**	236 mm
3.0 cm	246 mm	**3.0 cm**	250 mm
4.0 cm	258 mm	**4.0 cm**	261 mm
5.0 cm	272 mm	**5.0 cm**	278 mm

1.8.4.2 Ultrasonic Sensor(HC-SR04) Result Table

The analysis consists of two readings. Fixed water level is 1 cm to 5 cm need to be changed accordingly.

Table 1.6: Ultrasonic Sensor(HC-SR04) Data Reading Result for Indoor Environment

1st Data Reading		2nd Data Reading	
Manual (Fixed)	Output	**Manual (Fixed)**	Output
1.0 cm	1.0 cm	**1.0 cm**	1.0 cm
2.0 cm	2.0 cm	**2.0 cm**	2.0 cm
3.0 cm	3.0 cm	**3.0 cm**	3.0 cm
4.0 cm	4.0 cm	**4.0 cm**	4.0 cm
5.0 cm	5.0 cm	**5.0 cm**	5.0 cm

1.8.5 Result Discussion

Based on table 1.5 for the water level sensor data reading result, the output is in different format which is in millimeter(mm). Because this sensor only for alerting the user about the present of water droplet/water size in certain level.

Based on table 1.6 for ultrasonic sensor(HC-SR04) data reading result, the output is so accurate with the manual fixed measurement reading. According to (Varun, Kumar, Chowdary, & Raju, 2018) this is because ultrasonic sensor detects the object and measures the distance by following echo principle in this proposed system, water is also considered as object when a sound ray strikes water it results in generation of echo which is detected by the echo part of ultrasonic sensor. By measuring the time duration distance is determined.

As the conclusion, there are many limitations in water level sensor such as it is very sensitive sensor to detect the water present that will interrupt the reading result. Another limitation is that water level sensor output is clearly not accurate because of it use voltage to get the reading analog value. Also, as the project need to be portable, water level sensor needs to be exact depth of the water to take a reading. While ultrasonic sensor(HC-SR04), is not affected by many factors which is the output is accurate as the fixed water. Based on the analysis that had been made, ultrasonic sensor(HC-SR04) is more suitable for this project than water level sensor.

1.9 Report Organization

Chapter I: Introduction

In Chapter 1, the project explained about the definition, background study, problem statement, project question, project objective, project scope and expected output related to water quality monitoring of lakes and rivers.

Chapter II: Literature Review

Chapter 2 explains about the project will explain about a literature review whereby we collect analysis and data related to water quality monitoring from other sources such as journal, website, book, article etc.

Chapter III: Methodology

Chapter 3 will present the project will discuss about the methodology that are being use in this project. The methodology is required because it is important to carry out the method that will develop on this project. Based on methodology, it easy for to do system testing and correction because have timeline and guideline to follow.

Chapter IV: Design

In Chapter 4, the project will explain the design phase of the system with the details view to make the design implementation such as denoting an action or event preceding or done for this project and detailed design of the system project.

Chapter V: Implementation

Chapter 5 detailed about the project will be implementing the code and the logic process based on the project design.

Chapter VI: Testing

Chapter 6 explain about how the project will provide test case to be documented based on the system data input and the operating condition which is required to make a test product to collect the expected output result for system modules.

Chapter VII: Conclusion

This is last chapter which is to attach the entire chapter to make the documentation and state the project summarizations.

1.10 Conclusion

Finally, this project is aiming to achieve all the objective and to overcome the problem statement in this project. This assists the understanding of the reader about the project including the project background, objective and problem statement. In the next chapter the literature review is discussed, which describes about related works.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter explores related topic from other resources like journals, articles, books and others that have similarities. Several other research on water quality will be analyzed and compared to identify the suitable procedure and methodology that will be used in the project. Topics that will be compared is this chapter are on the design and implementation of the water quality monitoring system and the internet of things elements in their system. In addition, this chapter also will explore the issues related to this project problem based on their system platform, procedure or architecture.

Figure 2.1 shows the subtopic for this chapter. It includes Introduction, Microprocessor, Sensor, and Cloud Storage can be figure out through the literature review. This research is done to generate ideas and knowledge that used to develop water quality monitoring.

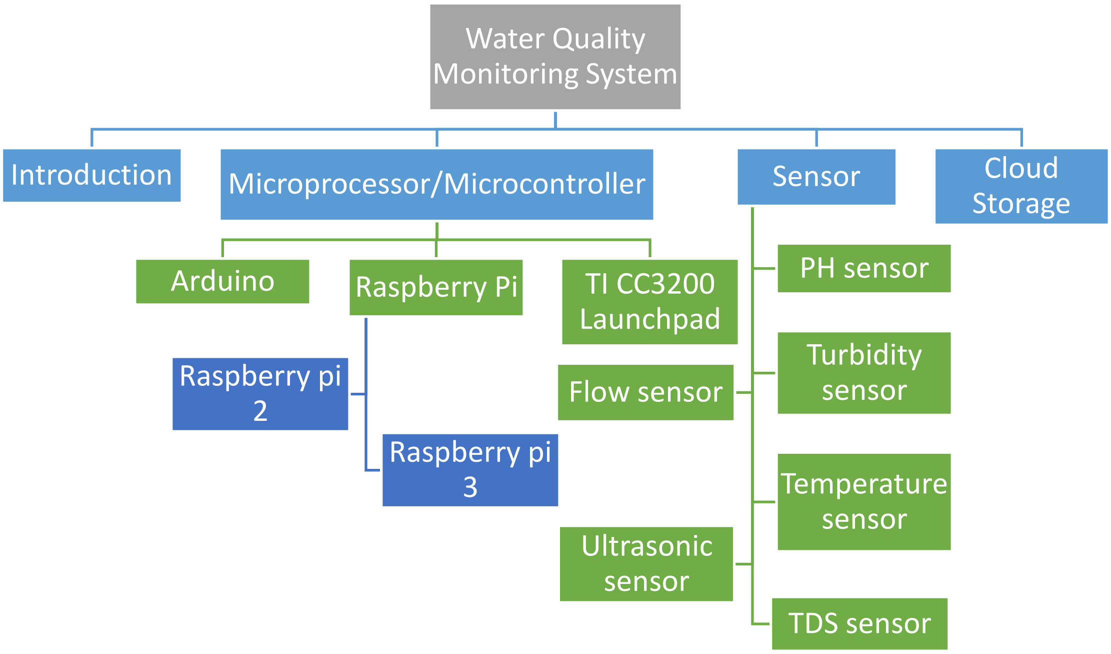

Figure 2.1: Overview of the Literature Review

2.2 Microprocessor/Microcontroller

Microprocessor/Microcontroller-based systems offer major advancement as an internal and external control. Microcontrollers can control majority of the internal devices in a typical circuit board. Moreover, majority of the chips also have built-in interfaces that can be controlled by the microcontroller (Raj, Rahman, & Anand, 2016). The microcontroller programming is done in traditional ‘C’ language. Microprocessors and microcontrollers provide the path for the integration of hardware and software (Edmondson, Tang, & Kern, 2008). There are five important components in a microprocessor. They are Arithmetic and Logic Unit (ALU), Control Unit, Registers, Instruction Decoder and Data Bus but the first three are considered significant components (Microprocessor and Microcontroller 2015). The block diagram of a microprocessor with these basic components is shown below.

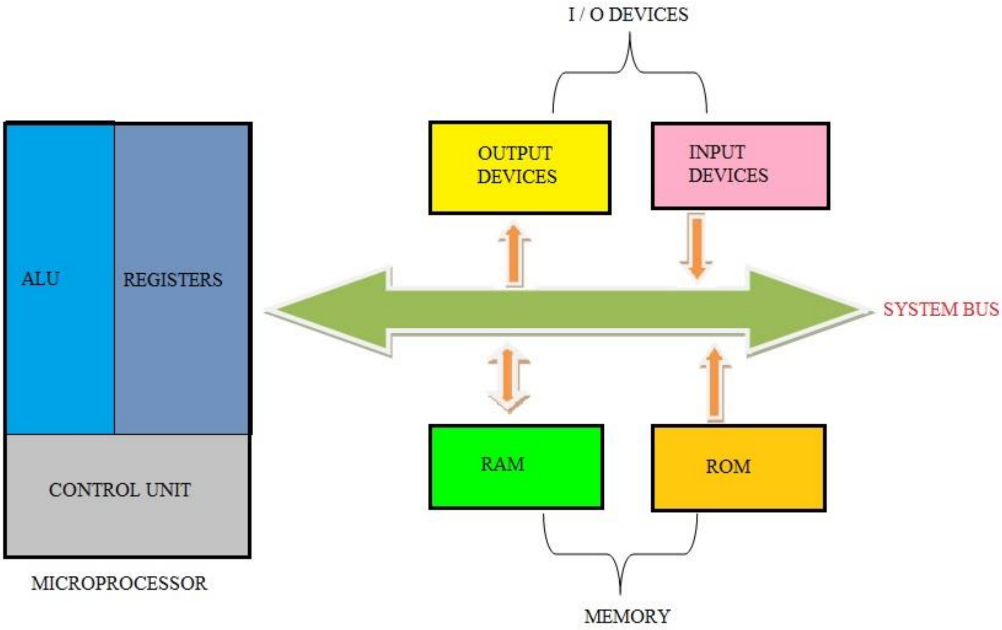

Figure 2.2: Block Diagram of a Microprocessor (Microprocessor and Microcontroller 2015)

2.2.1 Arduino

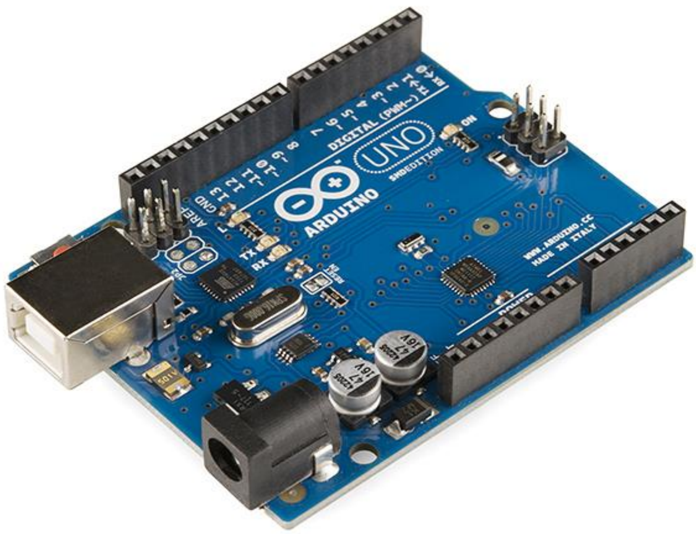

Figure 2.3: Arduino UNO R3 (Arduino UNO from Wikipedia 2019)

Arduino was designed in Italy in 2005 and since it is open source it facilitates hardware acquisition and implementation. Arduino is a multi-platform tool for Windows, Linux and Macintosh, based on IDE programming, and has a development environment based on C. However, its design accommodates some alterations that facilitate the understanding and the development of all end users (i.e. students, hobbyists and experienced developers) (Junior et al., 2013).

The UNO consists of an 8-bit ATMEL micro-controller, the ATmega328P, with an internal, permanent memory (EEPROM) for both code (including applications created by the students/developer) and data storage, and an internal volatile memory (RAM) for storage of temporary information. Another important feature of the Arduino UNO is its low-power consumption, since it can be powered by a simple 9V (volts) battery (Junior et al., 2013).

Table 2.1: Arduino UNO Specification

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	6-20V
Input Voltage (limits)	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin DC	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
Clock Speed	16 MHz

2.2.2 Raspberry Pi

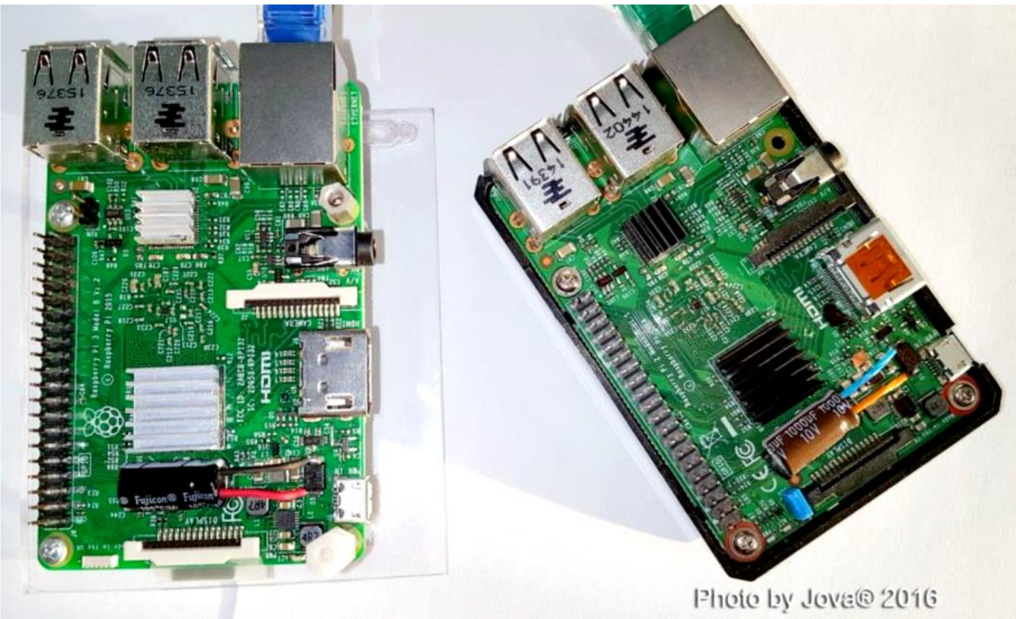

Figure 2.4: Raspberry Pi 2 and Raspberry Pi 3 (Ivković & Radulović, 2016)

Raspberry Pi is a small, powerful, cheap, hackable and education-oriented computer board introduced in 2012 This credit card-sized computer with many performances and affordable for 25-35$ is perfect platform for interfacing with many devices. The Raspberry Pi board contains a processor and graphics chip, program memory (RAM) and various interfaces and connectors for external devices. Some of these devices are essential, others are optional, but all Raspberry Pi models have the same CPU named BCM2835 which is cheap, powerful, and it does not consume a lot of power (Vujović & Maksimović, 2014).

Table 2.2: Comparison of Raspberry Pi 2 and Raspberry Pi 3 (Ivković & Radulović, 2016)

System	Raspberry Pi 2	Raspberry Pi 3
Release date	6th February 2015	29th February 2016
SoC IC	Broadcom BCM2836	Broadcom BCM2837

CPU	900MHz quad-core ARM Cortex-A7, ARM v7 generation	1.2GHz 64-bit quad-core ARM Cortex-A53, ARM v8 generation
GPU	Broadcom VideoCore IV on 250 MHz (BCM2837 GPU: 3D on 300 MHz, video part of on 400 MHz)	
Memory (SDRAM)	1GB LDDR2 400MHz (shared with GPU)	1GB LDDR3 900MHz (shared with GPU)
On-board network	100Mbit/s 802.3 Ethernet (WiFi using USB adapter)	100Mbit/s 802.3 Ethernet; 802.11n 150Mbit/s WiFi; Bluetooth 4.1
Power ratings	600 mA	800mA

2.2.3 TI CC3200 Launchpad

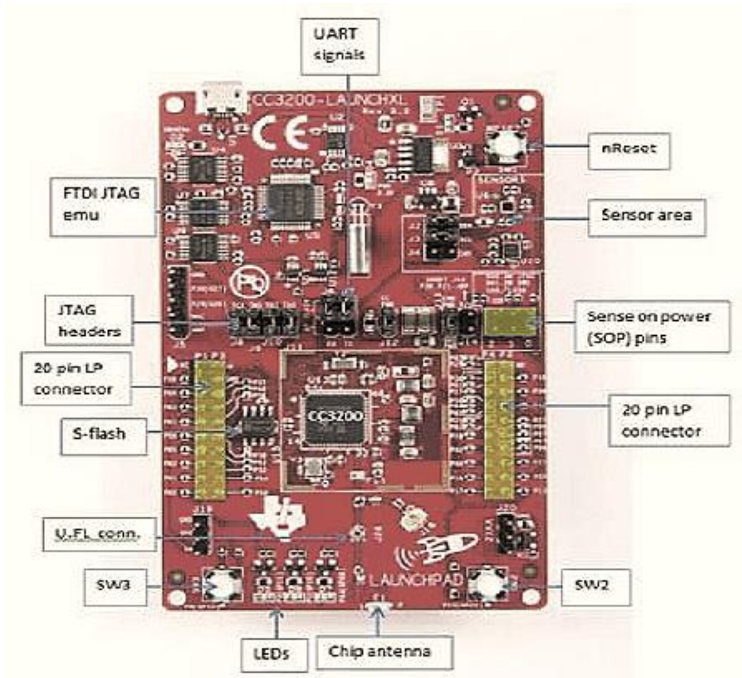

Figure 2.5: TI CC3200 Launchpad board (Kodali, Jain, Bose, & Boppana, 2017)

The TI CC3200 Launchpad consists of Applications Microcontroller, Wi-Fi Network Processor, and Power-Management subsystems. It uses ARM Cortex M4 Core Processor at 80 MHz. It has embedded memory including RAM (256 KB). The dedicated ARM micro-controller also has a network processing subsystem in it. Its features include:

- USB interface using FTDI USB drivers
- The board is powered through USB for the LaunchPad and external BoosterPack.
- It is operated from 2 AA- batteries.
- Standalone development platform provides features uch as sensors, LEDs and push-buttons.
- On-board antenna and U.FL connector can be selected using a capacitor re-work.
- It supports 4 wire JTAG and 2 Wire SWD
- GNU Debugger (GDB) supports over Open On chip debugger (OpenOCD)
- Two 20-pin connectors enable compatibility with BoosterPacks which have added functions
- Flash memory is updated through USB using SimpleLink Programmer

The board can be programmed through Energia IDE over the USB cable. The accessible Wi-Fi used by the board should be proxyless and can be of WPA or WEP type (Kodali et al., 2017).

2.3 Sensor

A device that responds to a physical stimulus (such as heat, light, sound, pressure, magnetism, or a particular motion) and transmits a resulting impulse (as for measurement or operating a control).

2.3.1 PH Sensor

The pH of thing is a useful constant to display because graduate and low pH levels can hump large effects on the author. The pH of a statement can grasps from 1 to 14. A pH sensor is an instrumentation that measures the hydrogen-ion density in a bleach, indicating its tartness or alkalinity. Its constitute varies from 0 to 14 pH. Uttermost pH values also process the solubility of elements and compounds making them cyanogenetic. Mathematically pH is referred as, pH = -log [H+] (Chowdury et al., 2019).

Figure 2.6: pH sensor (Anuadha T, 2018)

2.3.2 Turbidity Sensor

Turbidity sensor is used in measuring the standard of water in rivers and streams, wastewater and the efficient measurements, managing instrumentation for settling ponds, sediment transportation research are also in the laboratory measurements (Loganathan, Mohan, & Kumar, 2019).

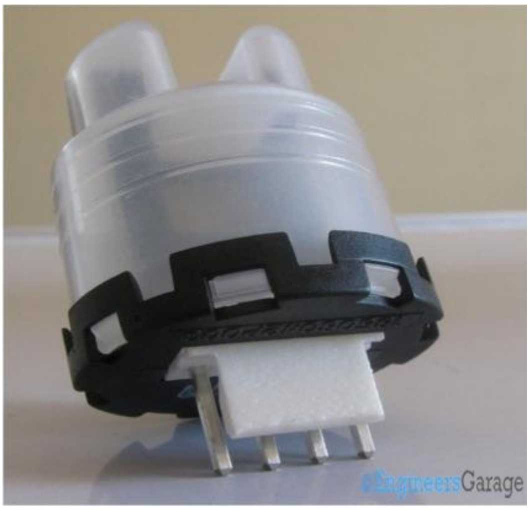

Figure 2.7: Turbidity Sensor (Loganathan et al., 2019)

2.3.3 Flow Sensor

Flow sensor is used for flow measurements to find the leakage in a pipe. Accurate flow measurement is an essential step both in the terms of qualitative and economic points of view. This sensor sits in line with the water line and contains a pinwheel sensor to measure how much water has moved through it. There is an integrated magnetic Hall-Effect sensor that outputs an electrical pulse with every revolution (Kawarkhe & Agrawal, 2019).

Figure 2.8: Flow Sensor (Kawarkhe & Agrawal, 2019)

2.3.4 Temperature Sensor

Temperature is a measure of how much heat is present in the water. To measure the temperature water its range is -55 to 125°C. The sealed digital temperature probe let to precisely measure temperatures in wet environments with a simple 1-Wire interface. It provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor. The pinout for this sensor is as follows: RED=VCC BLACK=GND WHITE=SIG (Anuadha T, 2018).

Figure 2.9: Temperature Sensor (Anuadha T, 2018).

2.3.5 Ultrasonic Sensor

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected as echo signals to the sensor, which itself computes the distance to the target based on the timespan between emitting the signal and receiving the echo. The ultrasonic sensor is used to measure the level of our water tank to avoid the overflow of water (Kawarkhe & Agrawal, 2019).

Figure 2.10: Ultrasonic Sensor (Kawarkhe & Agrawal, 2019).

2.3.6 TDS Sensor

TDS (Total Dissolved Solids) indicates how many milligrams of soluble solids are dissolved in one liter of water. In general, the higher the TDS value, the more soluble solids are dissolved in water, and the less clean the water is. Therefore, the TDS value can be used as one reference point for reflecting the cleanliness of water. This sensor supports 3.3 ~ 5.5V wide voltage input, and 0 ~ 2.3V analog voltage output, which makes it compatible with 5V or 3.3V control systems or boards (wiki.dfrobot.com n.d).

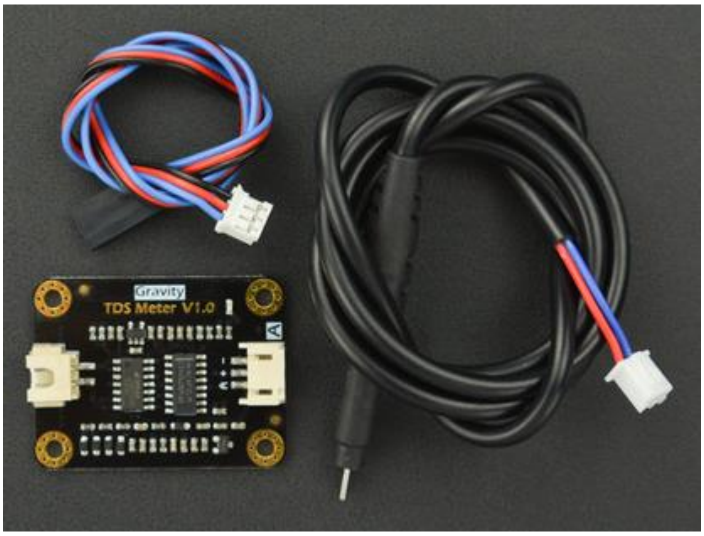

Figure 2.11: TDS Sensor (wiki.dfrobot.com n.d).

2.3.7 Cloud Storage

Cloud storage is a service model in which data is maintained, managed, backed up remotely and made available to users over a network (typically the Internet). Users generally pay for their cloud data storage on a per-consumption, monthly rate. Although the per-gigabyte cost has been radically driven down, cloud storage providers have added operating expenses that can make the technology more expensive than users bargained for. Cloud security continues to be a concern among users. Providers have tried to deal with those fears by building security capabilities, such as encryption and authentication, into their services (Margaret Rouse 2016).

2.4 Related Work

This part of related work to see the existing project. The research has done give the system to be develop more knowledge or creativity. There are five journals on the water quality monitoring project.

2.4.1 IoT Based Real-time River Water Quality Monitoring System

According to (Chowdury et al., 2019), the main aim is to develop a system for continuous monitoring of river water quality at remote places using wireless sensor networks with low power consumption, low-cost and high detection accuracy. pH, conductivity, turbidity level, etc. are the limits that are analyzed to improve the water quality. Following are the aims of idea implementation

- To measure water parameters such as pH, dissolved oxygen, turbidity, conductivity, etc. using available sensors at a remote place.

- To assemble data from various sensor nodes and send it to the base station by the wireless channel.

- To simulate and evaluate quality parameters for quality control.

- To send SMS to an authorized person routinely when water quality detected does not match the preset standards, so that, necessary actions can be taken. The detailed scheme of a water quality monitoring system is shown in Figure 2.2 .

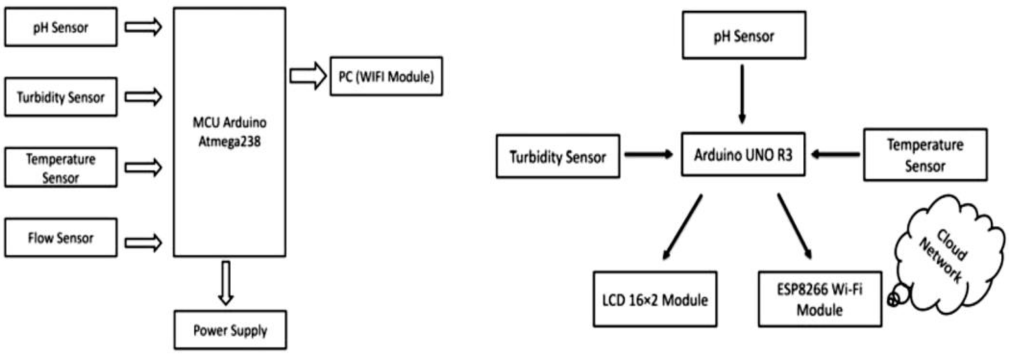

Figure 2.12: Block diagram and IoT Platform of the proposed system (Chowdury et al., 2019)

In the proposed architecture, each water reservoir will be attached with a sensor node equipped with a set of sensor probes capable of measuring the parameters like pH, turbidity etc. According to the specifications of the sensor probes and the processor board of the sensor the signal conditioning circuit will be designed to generate the sensor output to the processor board through Analog to Digital Converter.

The processor board processes the data according to the quality specifications and transmits to the central server through the transceiver. The measured data in each of the reservoir shall be sent to the central server through the respective transceivers either directly or indirectly through other sensor or repeater nodes (Chowdury et al., 2019).

2.4.2 Intelligent IoT Based Water Quality Monitoring System

According to (Pappu, Vudatha, Niharika, Karthick, & Sankaranarayanan, 2017), the challenge with the existing system is that there is no fully automated water Quality monitoring system employing Sensors. Also, system possess no intelligence as such which allows for analyzing the data for prediction. These systems so developed communicate within a small geographical area. So with the advent of Machine to Machine Communication leading to IoT, we here have developed an intelligent IoT based Water Quality monitoring system where PH and TDS Sensors deployed in water tanks in residential area which communicate through the Arduino Microcontroller to the Raspberry Pi3 processors where K-Means clustering machine learning algorithm deployed towards analyzing the data captured towards predicting the water quality as Good or bad. The predicted water Quality with PH and TDS for different types of water are updated in Webpage in Cloud for Water Department personnel to take action before affecting the residents. The complete system architecture of our IoT based System is shown in Figure 2.5.

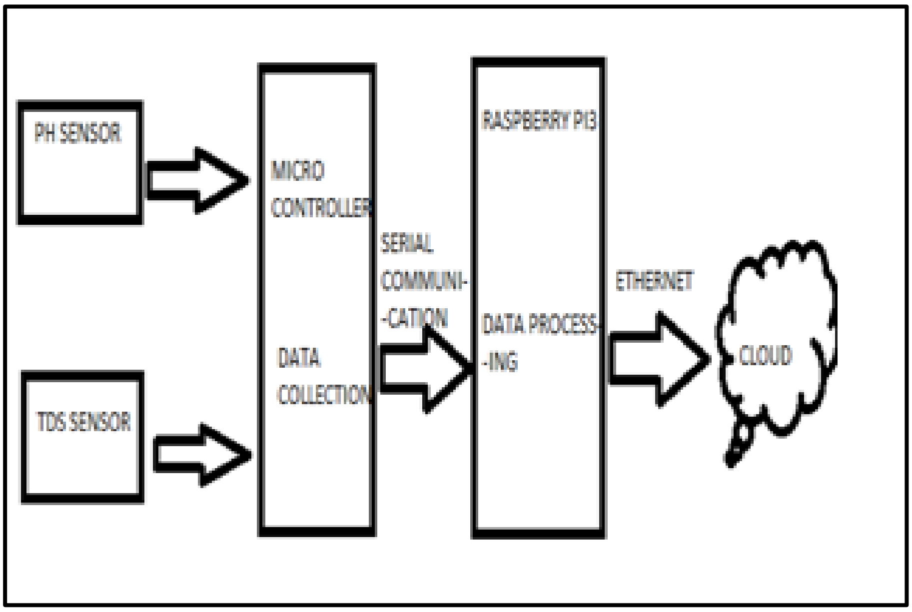

Figure 2.13: IoT Based Water Quality Monitoring System (Pappu et al., 2017)

The system here consists of three components. First component is the Arduino Microcontroller part where PH and TDS Sensor deployed in Water are connected to Microcontroller which gives the PH and Total dissolved solvents output based on Water Quality. The data received by Arduino are then sent to Edge level processor called the Raspberry Pi3 using Serial communication which is second component. In Pi3, K-Means Clustering Machine learning algorithm been employed for predicting the Water Quality based on PH and TDS.. The last and final component is recording the Water parameter and prediction with date and time in the cloud server for Water Authorities to access from their mobile to have good knowledge and understanding on water Quality being used by residents

For the implementation results and analysis, this project involved Arduino and Raspberry Pi3 as microcontroller and processing unit. In addition, PH and TDS Sensor deployed in water and same connected to Arduino microcontroller for collecting the water parameters which are hydrogen ion concentration and total dissolved solvents also the Arduino unit connected serially to Pi3 for communication of data for analysis where machine learning algorithm K-Means Cluster been developed. The results been updated in Cloud server. Raspberry Pi3 is the edge level processor where intelligent analysis been carried out towards captured PH and TDS data for prediction based on data trained for different types of water

2.4.3 IoT Based Water and Soil Quality Monitoring System

According to (Loganathan et al., 2019) the proposed system uses following sensors. pH, Moisture, Electric Conductivity (EC) and turbidity to get the data parameters. These sensors are arranged in the water will analyze the idea of the water resources. The checked substance is used to gauge the idea of water. The examined data is taken care of through the microcontroller and traded through the Wi-Fi module to the central server.

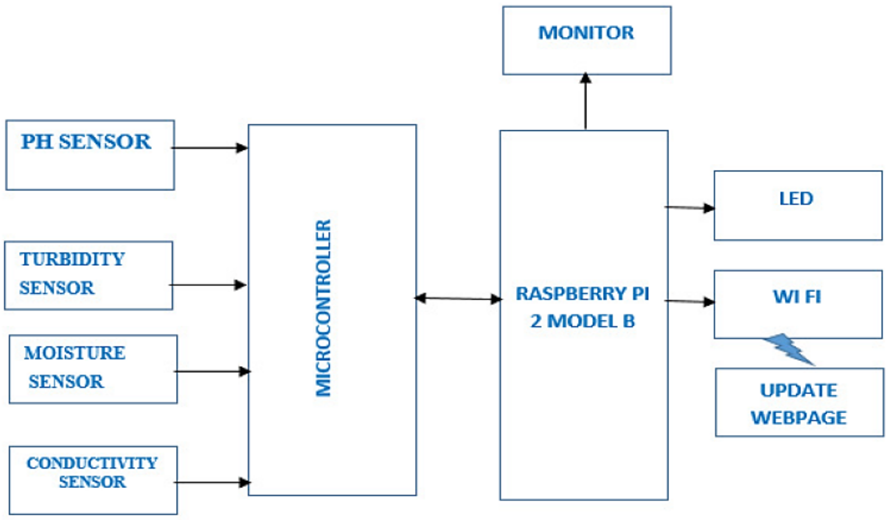

Figure 2.14: Water and Soil Monitoring System (Loganathan et al., 2019)

In this system it makes use of four sensors (Turbidity, pH, conductivity) and the microcontroller related with web of things. The Processing module microcontroller, and the transmission module GSM. The sensors get the data in the comparability signals. The ADC converter which covers the analog value to digital value of the sensed parameters. The modernized signs are passed to the controller which is as one with the transmission module (Loganathan et al., 2019).

2.4.4 The Monitoring of Water Quality in IoT Environment

According to (Anuadha T, 2018) the proposed method is used to overcome the drawbacks present in existing method. Here we are using Raspberry pi as core controller and various sensors to monitor the water Quality. Raspbian OS run on the

Raspberry pi to manage various types of equipments including sensor networks, so on. We are connecting different sensors Raspberry pi to monitor the conditions of water. The Raspberry pi will access the data from different sensors and then processes the data. The sensor data can be viewed on the cloud using a special IP address. Additionally, the IOT module also provides a Wi-Fi for viewing the data on mobile.

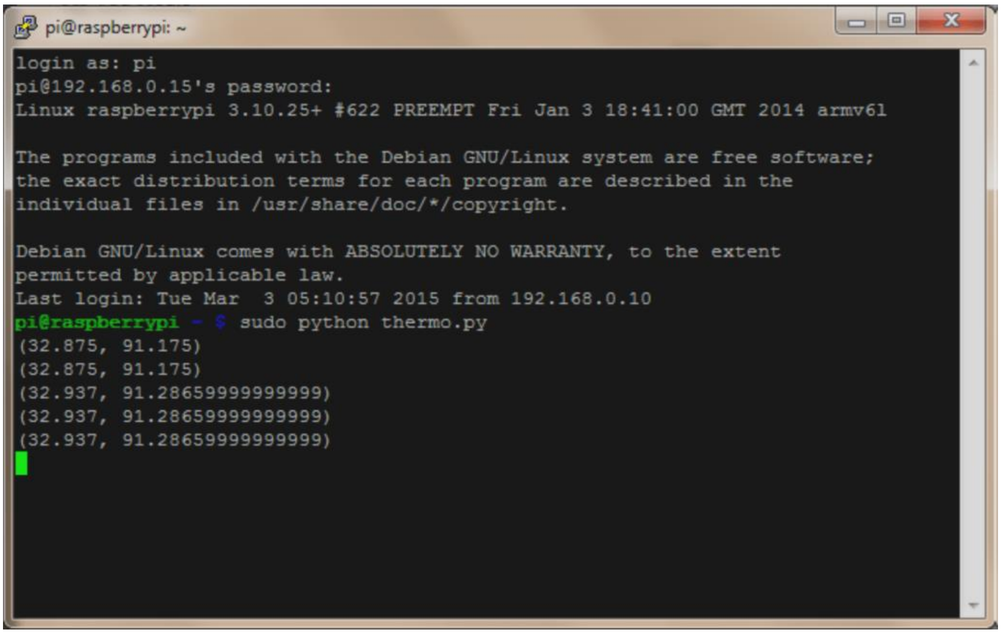

Figure 2.15: Testing Result (Anuadha T, 2018)

It has been developed by integrating features of all the hardware components and software used. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using highly advanced Raspberry Pi board and with the help of growing technology the project has been successfully implemented (Anuadha T, 2018).

2.4.5 IoT Enabled Real Time Water Quality Monitoring System

According to this authors (Geetha & Gouthami, 2016), the proposed work is aimed at domestic water quality monitoring. The sensors are assumed to be connected in-pipe. The controller and the sensors form a single module installed in the user premises. Therefore, the sensors are directly connected to controller. For applications such as lake, river and sea water monitoring, sensors and the controller are separated by considerable distance. The key parameters monitored in the proposed system are conductivity, turbidity, water level and pH value.

For communication between controller and the application, Wi-Fi is a compelling choice. With other short-range protocols, the sensor nodes communicate with controller easily, but when trying to connect the system to the Internet some type of adapter that is able to communicate with both the sensors and the Internet is needed. This is additional hardware overhead. With Wi-Fi, the above problem does not arise, because there is an infrastructure that is already built and is in existence.

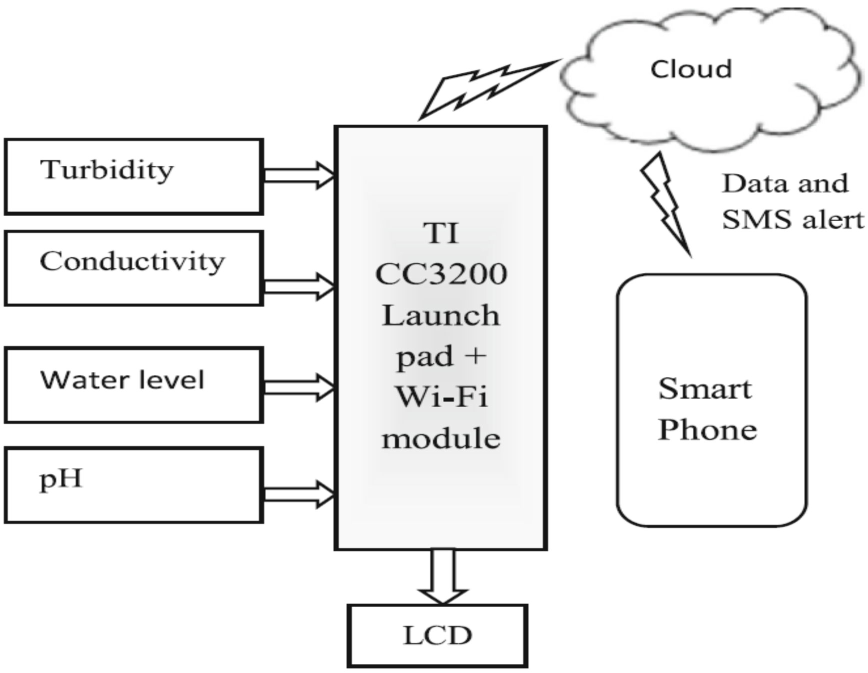

Figure 2.16: Block diagram of the proposed system (Geetha & Gouthami, 2016)

2.5 Critical Review

As part of the literature review, several works discussed in previous section by (Chowdury et al., 2019), (Pappu et al., 2017), (Loganathan et al., 2019), (Anuadha T, 2018), and (Geetha & Gouthami, 2016) will be compared and analyzed to identify the suitable methodologies, techniques, and component to be used in the project. Table 2.3 show the comparison of the previous work done by other researchers.

For (Chowdury et al., 2019), (Pappu et al., 2017), (Loganathan et al., 2019), and (Anuadha T, 2018) their water quality parameter does not cover real-time water level and DO sensor. Although (Geetha & Gouthami, 2016) monitoring system does cover real-time water level but it does not cover DO sensor. Thus, the level of dissolved oxygen in water is one of the most important parameters in determining its quality, because it indirectly indicates whether there is some kind of pollution (Ibanez, Hernandez-Esparza, Doria-Serrano, Fregoso-Infante, & Singh, 2008).

Table 2.3: Comparison of Related Work

Journal Name / Author	Sensor Type	Microcontroller	Functionality	Real-Time Water Level	Dissolved Oxygen Sensor
IoT Based Real-Time River Water Quality Monitoring System (Chowdury et al., 2019)	• pH sensor • Turbidity sensor • Temp sensor • Flow sensor	Arduino UNO	• Measure water parameter • Assemble data from various sensor nodes. • Send SMS when water not match the preset standard	✗	✗
Intelligent IoT Based Water Quality Monitoring System (Pappu et al., 2017)	• pH sensor • TDS sensor	• Raspberry Pi • Arduino	• Analyzing water quality	✗	✗
IoT Based Water and Soil Quality Monitoring System (Loganathan et al., 2019)	• pH sensor • Turbidity sensor • Moisture sensor • Conductivity sensor	• Raspberry Pi 2 • GSM module	• Checked substance is used to gauge the idea of water. • Analyze the idea of the water resources.	✗	✗
The Monitoring of Water Quality in IoT Environment (Anuadha T, 2018)	• pH sensor • Turbidity sensor • Temp sensor	Raspberry Pi	• Monitor the conditions of water • Sensor data can be viewed on the cloud using a special IP address	✗	✗
IoT Enabled Real Time Water Quality Monitoring System (Geetha & Gouthami, 2016)	• pH sensor • Turbidity sensor • Temp sensor • Water level sensor • Conductivity sensor	TI CC3200 Launchpad	• Sensors to be connected in-pipe. • Monitored in the proposed system are conductivity, turbidity, water level and pH	✓	✗
Proposed Project	• pH sensor • Temp sensor • Dissolved sensor • Turbidity sensor • Ultrasonic sensor	Arduino UNO	• Collecting water quality data in real time • Stored all the data on cloud • Provide a way to measure the water parameter • Able to alert certain threshold passed.	✓	✓

2.6 Proposed Solution

The main aim here is to develop a system for continuous monitoring of water quality at remote places using wireless sensor networks with low power consumption, low cost and high detection accuracy. pH value, turbidity level, dissolved oxygen, and temperature are the parameters that are analyzed to improve the water quality. The system will feature a microcontroller, Arduino UNO which will programmed to read data from multiple sensors to measure water quality then sends the data to a cloud storage platform. An Analog-to-Digital Converter will be used to convert data from analog to digital in order data is to readable. The data will be available to user online whether through a smartphone or other devices. The system also features a notification alert on the condition of the water quality if certain threshold were to be surpassed. Figure 2.4 below shows the diagram of the project proposed system.

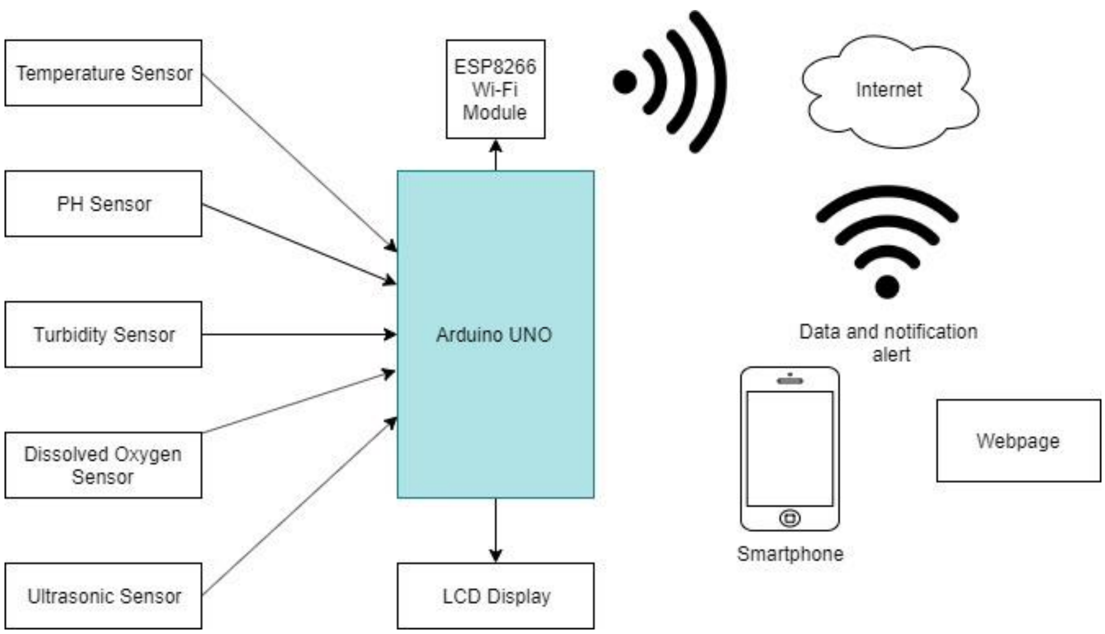

Figure 2.17: Diagram of Proposed System

2.7 Conclusion

In this chapter is discussing the literature review of the project which is existing project review to complete a good project. The analysis of system development will be discussed in detail. The literature review includes data gathering and information and problem analysis and requirements. All the result is derived from the analysis of the data collected and some conclusion and recommendation have been derived from the result of this chapter. From this chapter, we can make a comparison to choose a better project for reference. In the next chapter, methodology used for the project is discussed.

CHAPTER 3: METHODOLOGY

3.1 Introduction

Tables are printed within the body of the text at the center of the frame and labeled according to the chapter in which they appear. Thus, for example, tables in Chapter 3 are numbered sequentially: Table 3.1, Table 3.2. The label should be placed above the table itself and has the format shown in Table 3.1. Any text inside a table must follow “Table Text” style.

3.2 Project Development

The goals are to gather all information related to the development of IoT-Based Device for Real-Time Water Quality Monitoring System projects and software through the journal, articles, internet and books. The goal for the development of this project is to offer the solution from the manual method that are currently used and provide with better function and the lower the cost. This project begins on early semester where for the first half of this semester, is the part of introduction phase where author will do the research from the information that already gather and analyze the required information. The purpose is to determine the best solution for the project in terms of hardware selection and software related. The crucial phase to the development when the design is implemented into the real hardware and software then into the testing of function follow based on objective

3.3 Project Methodology

The methodology selected for this project is waterfall model which is known as the Software Development Life Cycle (SDLC). This model required to complete each of the phase before can proceed to the next phase and there would be no overlapping for each phase. The waterfall model often uses for the project that does not required for incremental on each phase and one of the popular strategies for (SDLC). The waterfall model consists of seven phase which is, evaluation, requirement, analysis, design, development, validation, deployment.

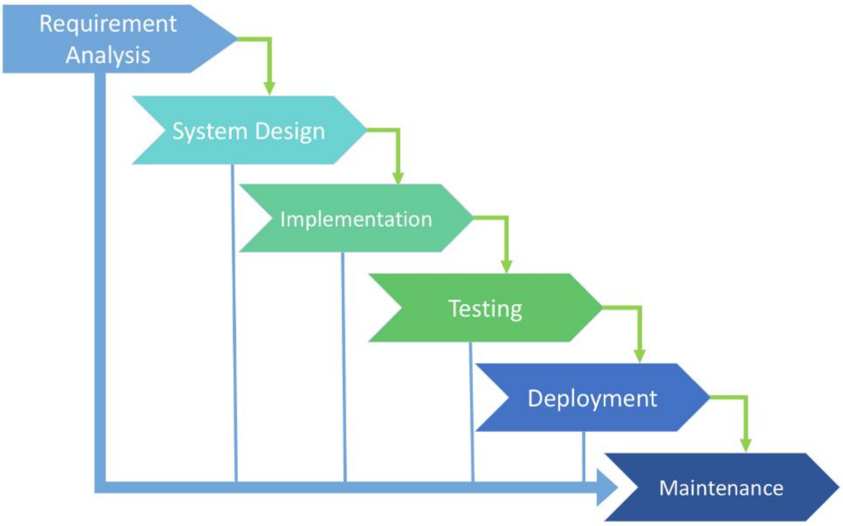

Figure 3.1: Waterfall SDLC Model (EXISTEK 2017)

3.3.1 Phase I: Requirements

SDLC model always start with the analysis, in which determines the project requirement for the final product. The purpose of this phase is to discuss the definition of the system requirement, software requirement and hardware requirement of the project. Besides, it is very important to understand the tasks and requirement that will be implemented into the project. The requirement of the project is discussed as below.

a. System Requirement

i. Collect Data and Monitor

The system must be able to collect data on the water quality based on the parameter which is pH value, turbidity and temperature. The system also allows the user to monitor the data on a real-time manner.

ii. **Notifications**

The device should be able to notify the user if the data surpassed certain threshold via E-mail or SMS

iii. **Test and Analysis**

Test the device by monitor the results via smartphone and provide statistical report that can be access remotely.

b. **Software Requirement**

i. **Arduino IDE -** An open-sources application used to write and upload code into the microcontroller board.

ii. **Blynk -** Smartphone based application that can retrieve data from IoT platform.

iii. **ThingSpeak -** An software that allows the data to be send/stores to cloud and able to access on website.

c. **Hardware Requirement**

i. **Arduino UNO** – A microcontroller kit to implement program to communicate with IoT devices

ii. **pH Sensor** – A sensor that capture the pH value of water quality.

iii. **Dissolve Oxygen Sensor** – A sensor to measure the concentration of dissolved oxygen in water samples being tested.

iv. **Ultrasonic Sensor –** A sensor that calculate the distance of water surface.

v. **Turbidity Sensor –** A sensor which measure the amount of light scattered in water.

vi. **Temperature Sensor –** A sensor that detect the temperature of water body.

vii. **Breadboard –** A tool to hold electrical components to allow device to communicate.

viii. **ESP 8266 –** A wireless adapter for Arduino Uno

3.3.2 Phase II: System Design

This section discussed about the architecture of the project. The requirement specification from the first phase are studied to create a system design. The design will help the defining the overall system architecture using the requirement specify in the first phase. The prototype design is to use the sensors to measure the water quality and sends the data Arduino Uno. All the program code will be written specifically to each sensor. Then, a circuit design of the connection between the sensor, microcontroller and microchip on the breadboard is drafted

3.3.3 Phase III: Implementation

In this phase, all the program code will be written and tested into the Arduino UNO using a program call Arduino IDE which handles the C++ development environment. After that, the sensor and microcontroller connection is tested with the coding written earlier to ensure the accurate readings of measurement. Then, an application called Blynk is installed into a smartphone and further configuration is on the application is needed to communicate with the microcontroller. The application will retrieve the readings from the microcontroller and displayed on the application.

3.3.4 Phase V: Deployment

The functional and non-functional of the hardware and system is done testing, the project is now ready for the deployment and used in real environment. This phase is coming when the testing phase is clear from the bug or error or any issues and it will deploy for the production and used by the end users.

3.3.5 Phase VI: Maintenance

The objective of the maintenance phase is to keep to system and hardware is functional correctly. This phase is required the author to monitor the product that already produce and provide with the bug fixes and ready to receive the report from the end user regarding to the product. It is necessary to provide new update and patches for the product when it is available to the end user.

3.4 Project Milestone

Project milestone was timeline that will ensure the completeness of the system based on the specific timeframe. The project milestone consists of the project flow, which is the start and completion time of the project. The milestone was also being used to estimate the duration its need to complete the project.

Table 3.1: Project Milestones

Phase	Activity
Phase 1: Requirement	- Project Proposal - Proposal assessment & verification - Proposal Correction/Improvement - Proposal Presentation & Submission - Identify project requirement - Identify the objectives, scope and problem statement
Phase 2: System Designs	- Design the architecture of the project - Construct a flow chart which determine the flow of the project. - Define the connection to be made in the projects - Determine the system environment needed for the device
Phase 3: Implementation	- Write and upload code into the device - Calibrate sensors - Set up connection with the Blynk
Phase 4: Testing	- Debugging the prototype for error and flaws - Develop test cases for the prototype to identify errors - Prototype is tested into real environment scenarios
Phase 5: Deployment	- Test the prototype with users - Collect feedback from users
Phase 6: Maintenance	- Monitor the product for any errors and bug

3.5 Project Gantt Chart

Table 3.2: Project Gantt Chart

Task Name	Week														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Phase 1															
Phase 2															
Phase 3															
Phase 4															
Phase 5															
Phase 6															

3.6 Conclusion

In conclusion, the SDLC Waterfall Model methodology is selected to help the project progression and to deliver the project efficiently before the deadline. This chapter also show the step by step analysis of the stages of the project determine by the methodology selected. The project milestones stated earlier is to track the project progression and complete the project according to the given timeline of the project. As for the next chapter, analysis and architecture will be discussed and detailed. A complete detail structure of the program will be described in the next chapter.

CHAPTER 4: ANALYSIS AND DESIGN

4.1 Introduction

This chapter presents and discusses the analysis and requirement of the project to properly plan and prepare for the project. Besides that, the chapter also focuses on the project problem before proceeding with the requirement and the design of the project. This technique of analysis will help the development of the project. The next process is the design phase where it will contain the expected result of the project. The requirement of the hardware and software are all include in this chapter where it describes about the functionality and the architecture of the system and the hardware. The system design will be including in this chapter to view how the system will function and understanding the flow of the system.

4.2 Problem Analysis

Pollution have become more serious in the coming years of the lives of living things which can lead to troubles into the environment. One of the problems is water contamination in the surface waters of the environment such as rivers, lakes, coastal seas and other water bodies. Water quality monitoring can help to control the problem and help authorities to take action to the problem arise in the water defilement problems. Water quality monitoring in very practical but sometimes hard to gather. The data must be collected and analyze in order to take actions on the problem that the environment is facing. The most common method to detect these parameters is to collect samples manually and then send them to laboratory for detecting and analyzing. This method wastes too much manpower and material resource, and has the limitations of the samples collecting, long-time analyzing, the aging of demonstration equipment and other issues. Besides, the manual method also can lead into inconsistent results which can cause many irregularities in the data itself.

4.3 Requirement Analysis

Requirement analysis is related to the process of determine the requirement of the project. It is and important task and process and need to provide with the accurate information. This subtopic will discuss about the data requirement, function requirement, non-functional requirement and other related requirement which is software and hardware requirement for the project.

4.3.1 Data Requirement

The product will have a design that should have the input and output because the system will be interacting with the hardware. For this project, the input and output data which is digital data in terms of pH value, water turbidity level and temperature of the water tested. The hardware which is the sensors will collect the input and send to a microchip to be converted into digital signal. The signal then will be displayed through a cloud platform application called Blynk. In order to achieve accuracy, each sensor must be calibrated because no sensor is perfect especially analog sensor. Calibration is a crucial step in order to achieve accurate readings.

4.3.2 Software Requirement

The required software for this project is listed as below:

a) Arduino IDE

Figure 4.1: Arduino IDE software

An open-source application which is used to write and upload code to different type of microcontroller board.

b) Blynk

Figure 4.2: Blynk Application

Blynk is a Platform with IOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets. This application allows multiple function such as create amazing interfaces and acts as a server responsible for communication between the smartphone and the hardware.

c) ThingSpeak

Figure 4.3: ThingSpeak software

ThingSpeak is a platform IoT analytics service that enables you to aggregate, view and analyze live data streams in the cloud. ThingSpeak provides instant display of information posted to ThingSpeak by the devices.

4.3.3 Hardware Requirement

a) Arduino UNO

Figure 4.4: Arduino UNO

The Arduino UNO in Figure 4.1 is one of the Arduino microcontroller family which is the most used among the Arduino family. It is also the most robust and easy to use board

b) HC-SR04 Ultrasonic Sensor

Figure 4.5: HC-SR04 Ultrasonic sensor

The HC-SR04 Ultrasonic sensor in Figure 4.2 is designed to measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and receiver.

c) Analog PH Sensor

Figure 4.6: Analog pH Sensor

The pH Sensor in Figure 4.2 is designed to measure the pH value of water and shows the acidity of alkalinity. This sensor is usually used to many applications in various related fields such as aquaponics, aquaculture and other environmental testing

d) Analog/Digital Turbidity Sensor

Figure 4.7: Analog/Digital Turbidity Sensor

This turbidity sensor in Figure 4.4 is designed to detects the water quality by measuring the turbidity level of the water. The sensor allows to detect suspended particles in water by measuring the light transmittance and scattering rate which changes with the amount of total suspended solids (TSS) in water.

e) Waterproof DS18B20 Digital Temperature Sensor

Figure 4.8: Waterproof DS18B20 Digital Temperature Sensor

This sensor in Figure 4.5 is designed to measure the temperature of water. It is a waterproofed version of the DS18B20 temperature sensor. It can operate in water up to 125 degrees Celsius.

f) Gravity: Analog Dissolved Oxygen Sensor

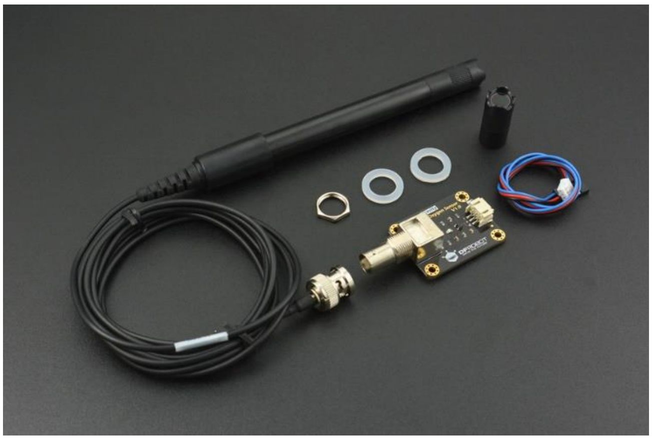

Figure 4.9: Gravity: Analog Dissolved Oxygen Sensor

This sensor in Figure 4.6 is used to measure the dissolved oxygen in water, which in turn reflects the water quality. It is widely applied in many water quality applications, such as aquaculture, environmental monitoring, natural science and so on.

g) Breadboard

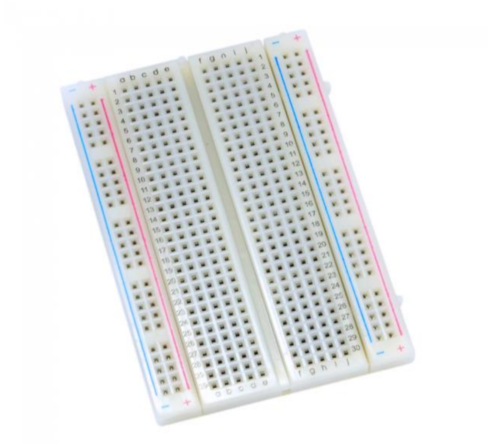

Figure 4.10: Breadboard

Figure 4.7 shows a breadboard which is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connect the holes on the top of the board.

h) ESP 8266 Wi-Fi Module

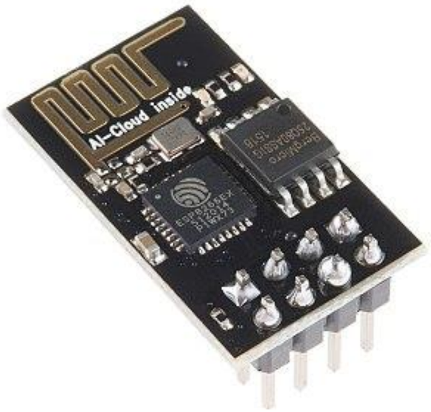

Figure 4.11: ESP 8266 Wi-Fi Module

In figure 4. Above shows an ESP 8266 which is a microchip that provide Wi-Fi capability to the Arduino board. This small module can help the board to connects to a Wi-Fi network and make a TCP/IP connection.

i) I2C LCD Display 16x2

Figure 4.12: I2C LCD Display 16x2

This LCD 16x2 White on Blue Display is a small HD44780-based screen capable of displaying up to 16 characters and 2 lines in alphanumerical or Japanese Kana characters, with space for up to 8 extra characters or symbols or “Foreign characters” of your choice as well. This LCD is that it utilizes a single LED backlight that can be dimmed with a resistor or PWM.

j) Jumper Wire

Figure 4.13: Jumper Wire

A jumper wire is an electrical wire that consist a connected pin which used for interconnecting the items on the breadboard for prototyping or circuit testing with the need of soldering. There are three type of jumper wire which is male-to-male, female-to-female, and male-to-female.

k) Power Bank

Figure 4.14: Power Bank

Power banks can be describe as portable batteries that can control power flow with a special circuit. It allows user to store electrical energy then later use it to power up any device by providing an output of 5 Volts.

4.4 Detailed Design

This section shows the detailed design of the project where it will contain the structure view of the system to be developed which including the circuit diagram, architecture design, interface design and flow chart of the system.

4.4.1 Circuit Diagram

a) HC-SR04 Ultrasonic Sensor Circuit Design

Figure 4.11 show circuit design for HC-SR04 ultrasonic sensor. It has 4 pin which is VCC pin, Trig pin, Echo pin, and GND pin. It uses 5v input.

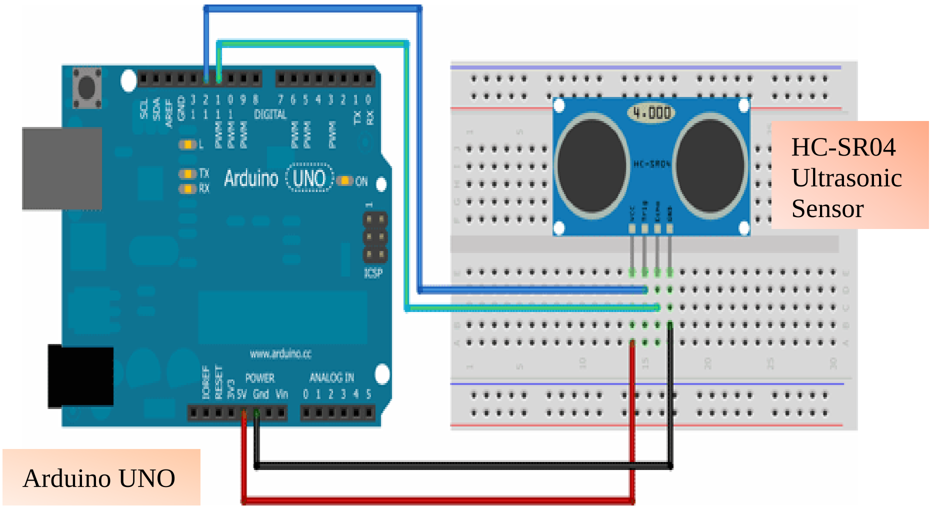

Figure 4.15: HC-SR04 Ultrasonic Sensor Circuit Design

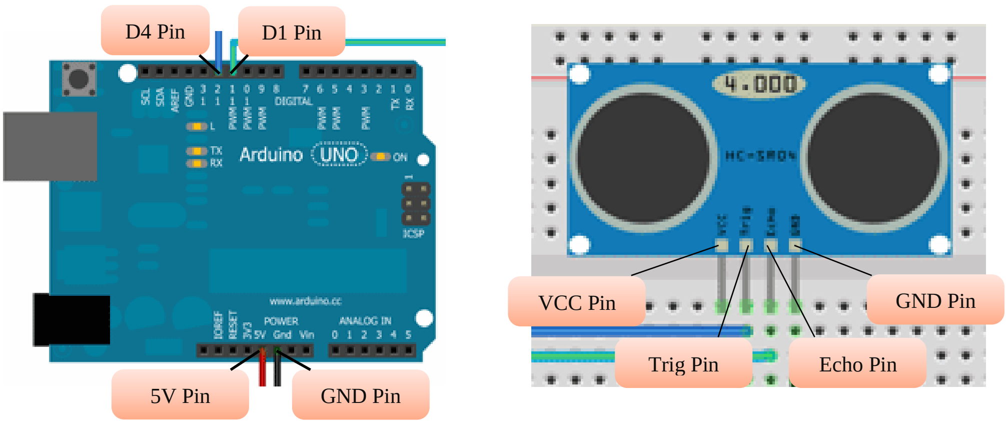

Figure 4.16: Pin Connection for the sensor and Arduino board

b) Analog PH Sensor Circuit Design

The onboard voltage regulator chip supports the wide voltage supply of 3.3~5.5V, which is compatible with 5V and 3.3V main control board. It has addition board called pH signal conversion board that has 4 connection (GND, VCC, Analog output, probe connector). Figure 4.13 shows analog pH sensor circuit design.

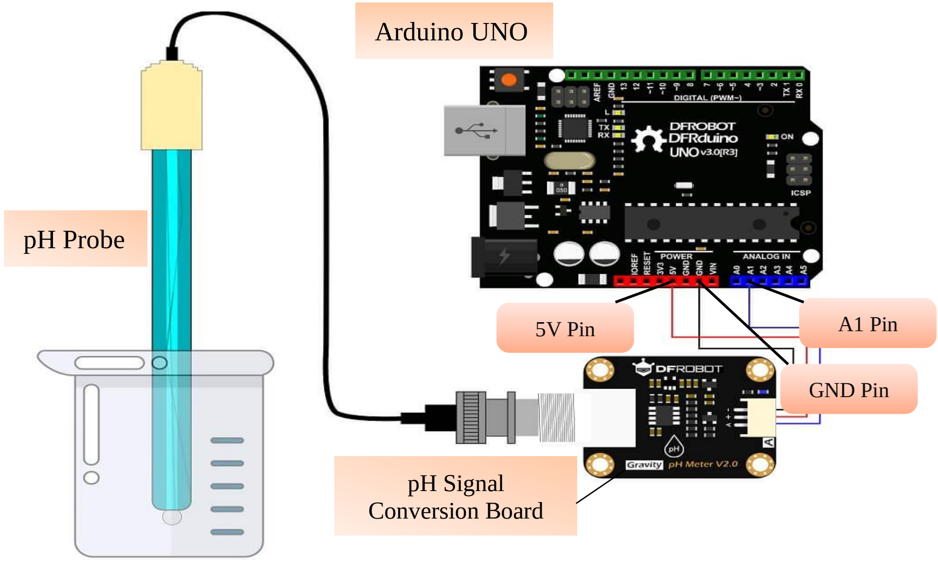

Figure 4.17: Analog PH Sensor Circuit Design

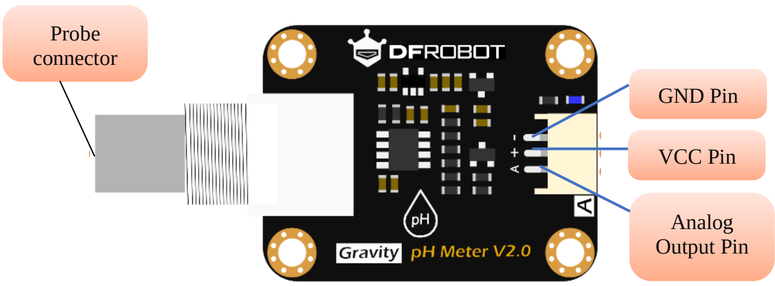

Figure 4.18: PH signal conversion board connection

c) Analog/Digital Turbidity Sensor Circuit Design

It detects water quality by measuring the levels of turbidity, or the opaqueness. It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. Figure 4.15 shows analog/digital turbidity sensor circuit design

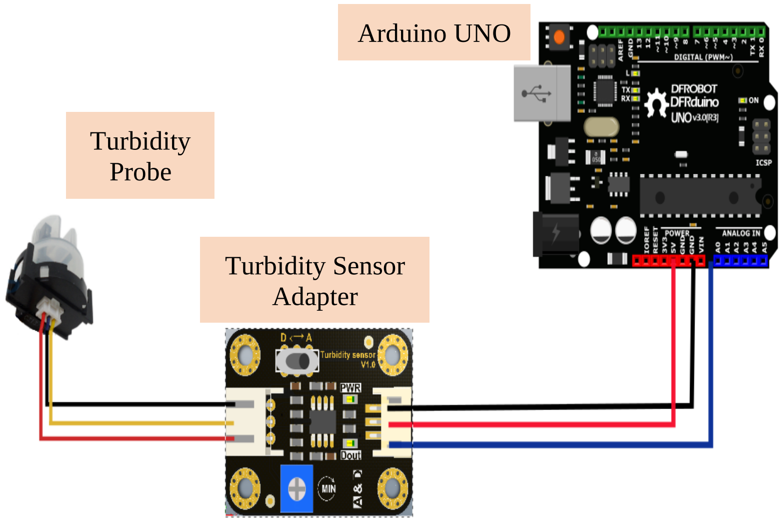

Figure 4.19: Analog/Digital Turbidity Sensor Circuit Design

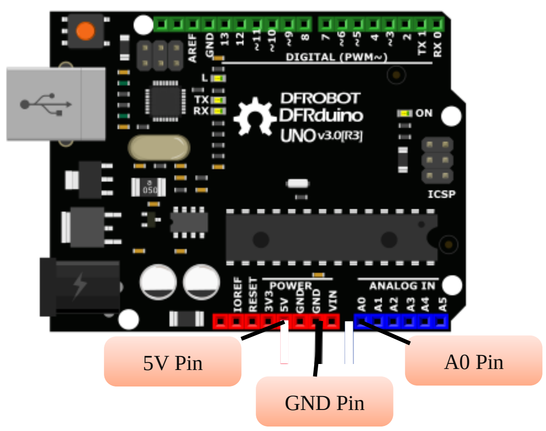

Figure 4.20: Pin Connection for the sensor to Arduino board

d) Waterproof DS18B20 Digital Temperature Sensor Circuit Design

This sensor able to hold up to 125°C. The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor. Usable with 3.0-5.5V systems. Figure 4.17 show Waterproof DS18B20 Digital Temperature Sensor Circuit Design. For wires temperature connection refer table 4.1.

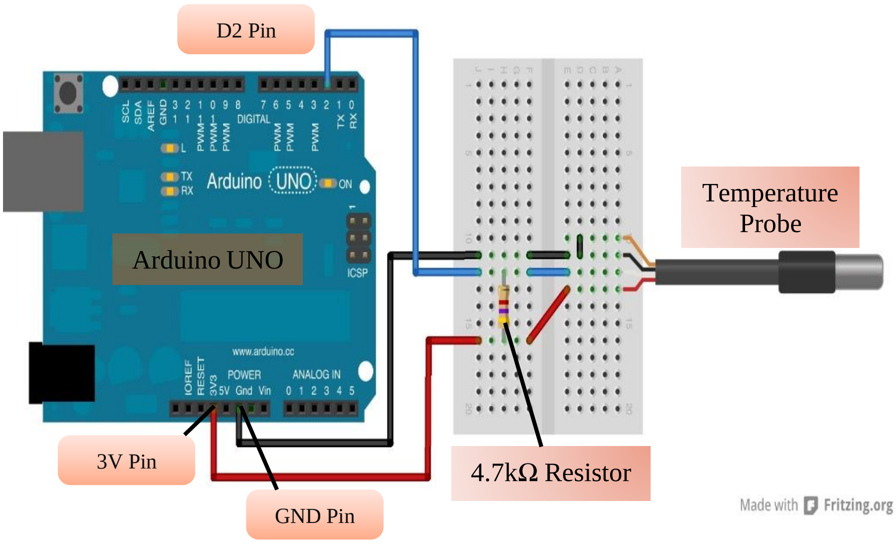

Figure 4.21: Waterproof DS18B20 Digital Temperature Sensor Circuit Design

Table 4.1: Three wires interface

Red Wire	VCC
Black Wire	GND
Yellow Wire	DATA

e) Gravity: Analog Dissolved Oxygen Sensor Circuit Design

Used to measure the dissolved oxygen in water, which in turn reflects the water quality. This sensor can hold up to 40°C. the filling solution need to be added in sensor probe to get the reading. It has single converter board for calibration converter. Figure 4.18 below show gravity: analog dissolved oxygen sensor circuit design

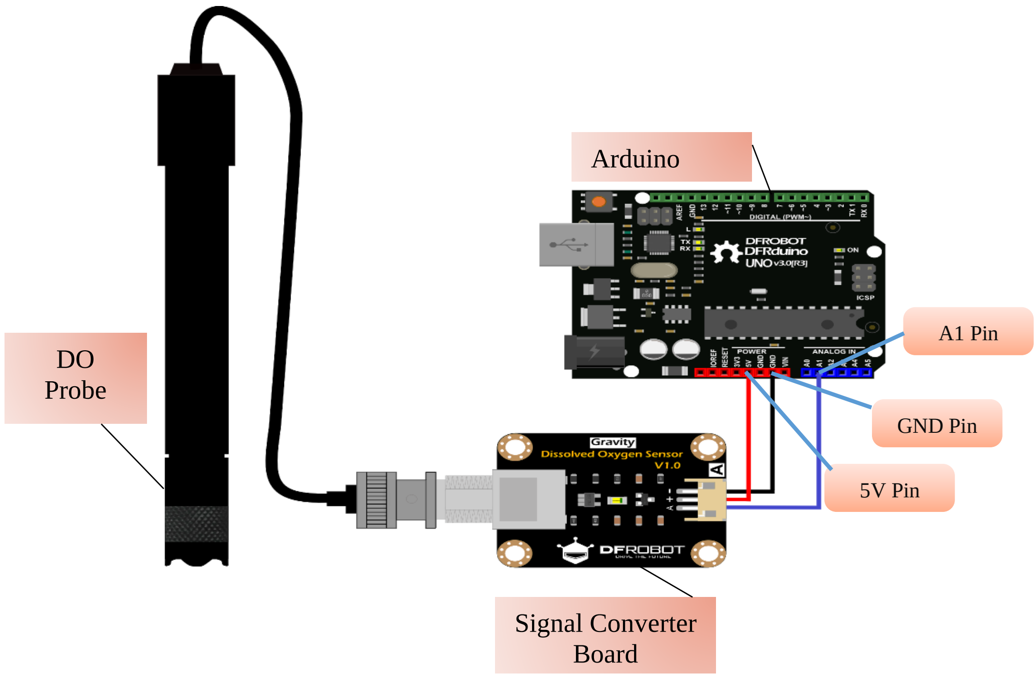

Figure 4.22: Gravity: Analog Dissolved Oxygen Sensor Circuit Design

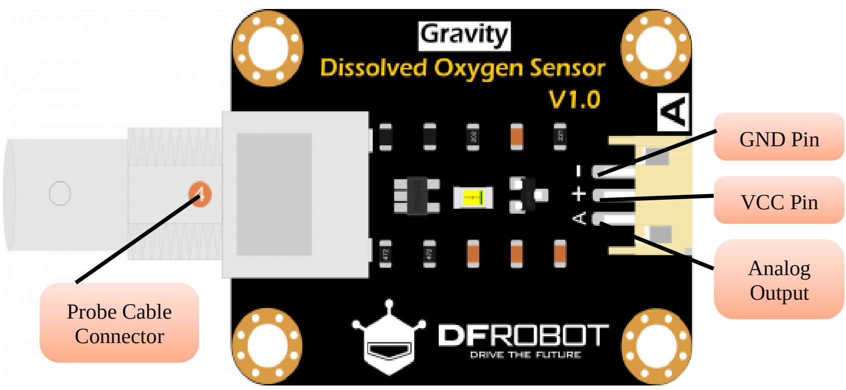

Figure 4.23: Signal Converter Board

4.4.2 Architecture Design

The system will feature a microcontroller, Arduino UNO which will programmed to read data from multiple sensors to measure water quality then sends the data via ESP8266 Wi-Fi module to a cloud storage platform. The data will be available to user online whether through a smartphone or other devices. The system also features a notification alert on the condition of the water quality if certain threshold were to be surpassed using an application called Blynk. ThingSpeak software will be uses for stores all the to be generate as report. This system uses power bank as power supply to make it portable. Figure 4.20 below shows the architecture design of the project.

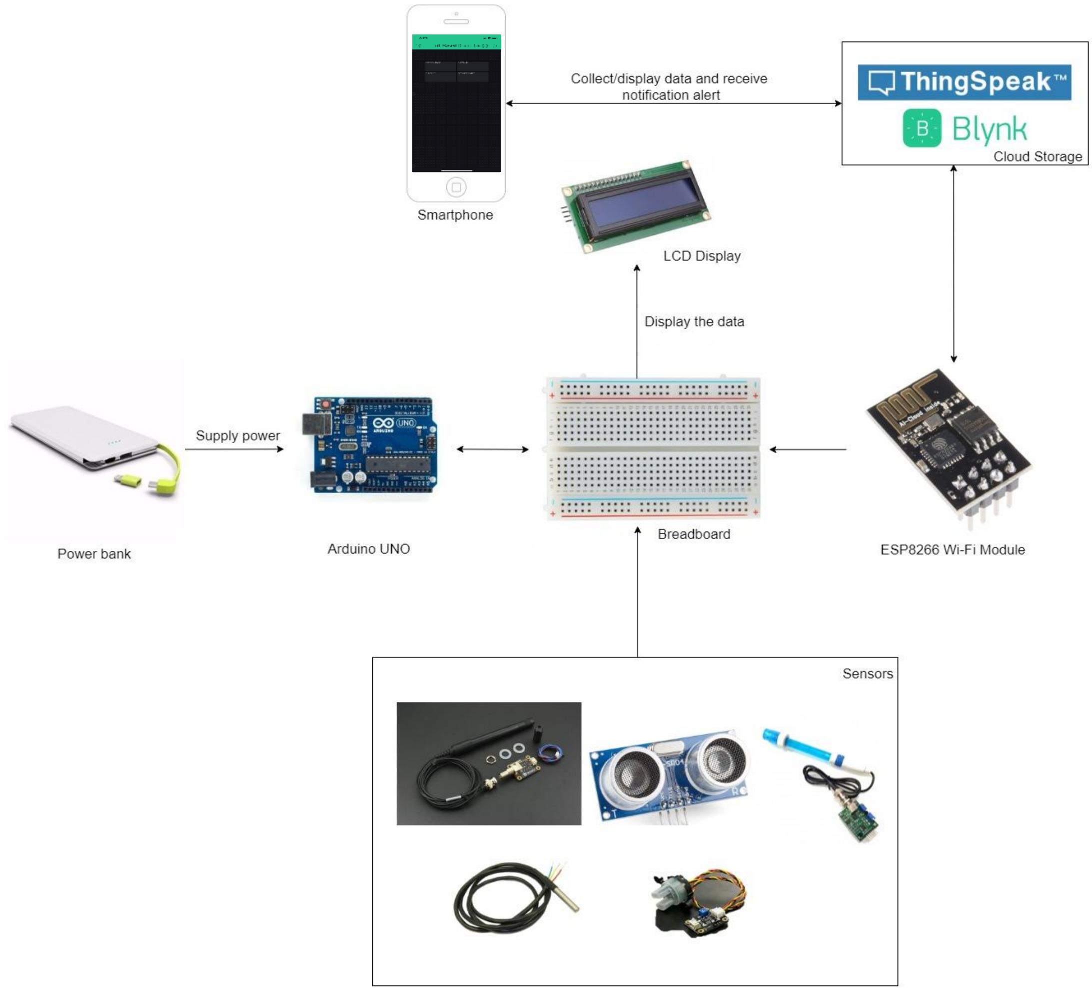

Figure 4.24: The architecture design of the project

4.4.3 Interface Design

Interface design is Design is the process of making interfaces with a focus on looks or style in software or computer devices. Good interface design is user-friendly, and the design is easy to use by whole community. Figure 4.21 shows the sketch design of blynk application. The design will display the parameter of the water quality such as temperature level, pH value, turbidity level, DO value, and water level.

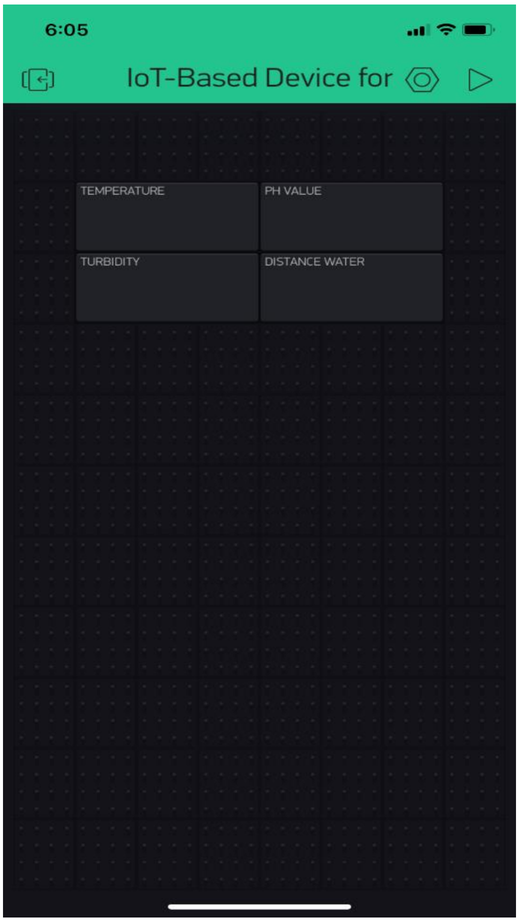

Figure 4.25: Example of interface design

4.4.4 Flow Chart

Flowchart is a formalized graphic representation of a logic sequence of the system. In the design phase flowchart is one part of the project development. This flowchart shows the flow of the system functionality start from the device to the monitoring part of the project.

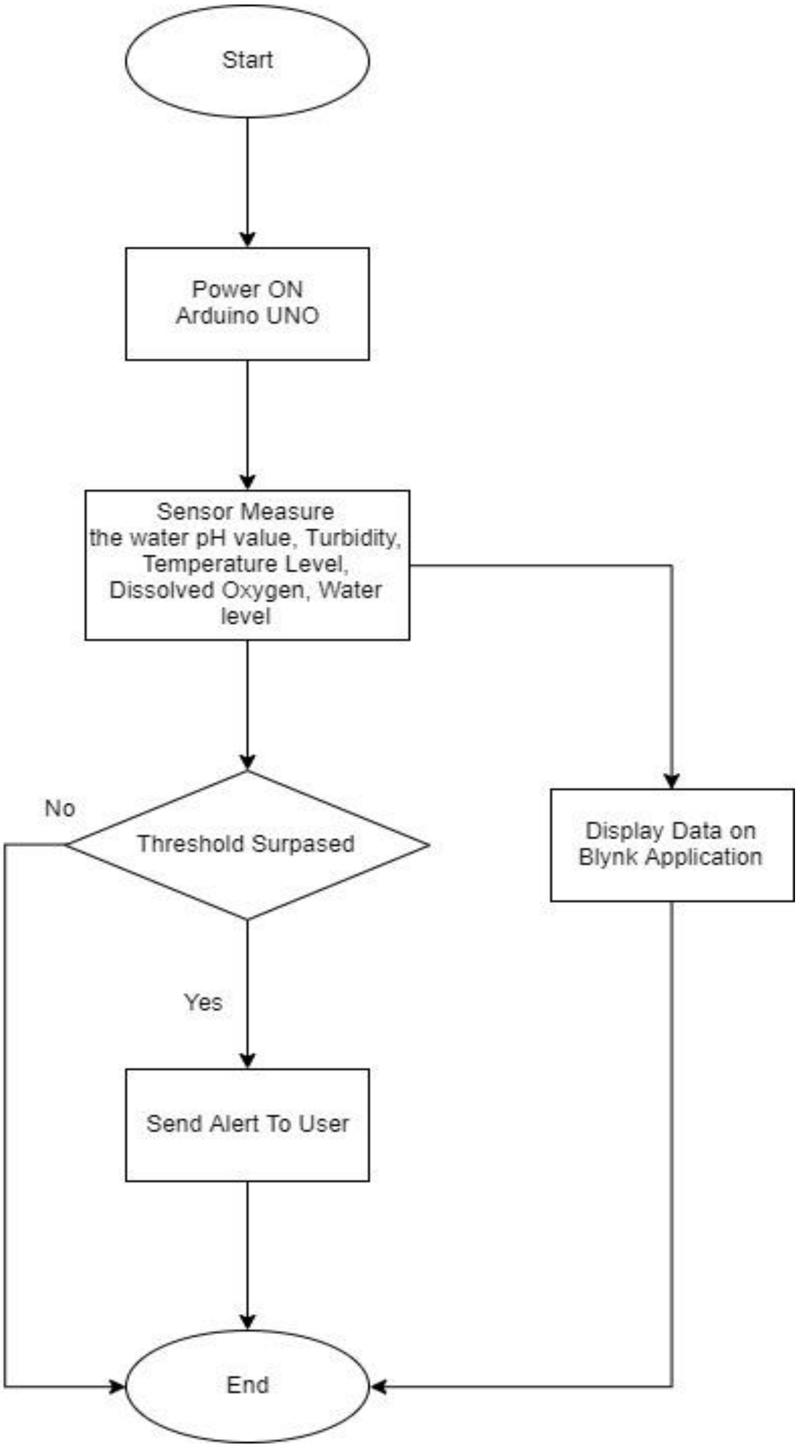

Figure 4.26: Flowchart of The System

4.5 Conclusion

As the conclusion, this chapter is important to be clearly discuss before going to the next chapter which the implementation phase. This chapter discuss about all the requirement include the software and hardware requirement. Moreover, this chapter show the design of the system and the flow chart of the system.

REFERENCES

Anuadha T. (2018). *The Monitoring of Water Quality in IoT Environment*. *4*(5), 903–907.

Chowdury, M. S. U., Emran, T. Bin, Ghosh, S., Pathak, A., Alam, M. M., Absar, N., … Hossain, M. S. (2019). IoT based real-time river water quality monitoring system. *Procedia Computer Science*, *155*, 161–168. https://doi.org/10.1016/j.procs.2019.08.025

Drahansky, M., Paridah, M. ., Moradbak, A., Mohamed, A. ., Owolabi, F. abdulwahab taiwo, Asniza, M., & Abdul Khalid, S. H. . (2016). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %. *Intech*, *i*(tourism), 13. https://doi.org/http://dx.doi.org/10.5772/57353

Edmondson, M. C., Tang, L., & Kern, A. (2008). Software development modules for microcontroller-based system. *CIMTEC 2008 - Proceedings of the 3rd International Conference on Smart Materials, Structures and Systems - Emboding Intelligence in Structures and Integrated Systems*, *56*, 45–51. https://doi.org/10.4028/www.scientific.net/AST.56.45

Farm, A., A, N. A. A., Abustan, I., & Mahyun, A. W. (2013). *AWAM International Conference on Civil Engineering & Geohazard Information Zonation Water Quality Monitoring on Golden Arowana (Scleropages formosus)*. *2*, 190–196.

Geetha, S., & Gouthami, S. (2016). Internet of things enabled real time water quality monitoring system. *Smart Water*, *2*(1), 1–19. https://doi.org/10.1186/s40713-017-0005-y

Ibanez, J. G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A., & Singh, M. M. (2008). *The Point of Zero Charge of Oxides In: Environmental Chemistry*. (January 2008), 70–78. https://doi.org/10.1007/978-0-387-49493-7

Ivković, J., & Radulović, B. (2016). *The Advantages of Using Raspberry Pi 3 Compared to Raspberry Pi 2 SoC Computers for Sensor System Support*. (January 2017), 88–94. https://doi.org/10.20544/aiit2016.12

Junior, L. A., Neto, O. T., Hernandez, M. F., Martins, P. S., Roger, L. L., & Guerra,

F. A. (2013). A Low-Cost and Simple Arduino-Based Educational Robotics Kit. *Journal of Selected Areas in Robotics and Control (JSRC)*, *3*(12), 12. Retrieved from http://blog.minibloq.org/

Kawarkhe, M. B., & Agrawal, S. (2019). *Smart Water Monitoring System Using IOT at Home*. *21*(1), 14–19. https://doi.org/10.9790/0661-2101021419

Kodali, R. K., Jain, V., Bose, S., & Boppana, L. (2017). IoT based smart security and home automation system. *Proceeding - IEEE International Conference on Computing, Communication and Automation, ICCCA 2016*, (October 2017), 1286–1289. https://doi.org/10.1109/CCAA.2016.7813916

Loganathan, G. B., Mohan, E., & Kumar, R. S. (2019). IoT based water and soil quality monitoring system. *International Journal of Mechanical Engineering and Technology*, *10*(2), 537–541.

Pappu, S., Vudatha, P., Niharika, A. V., Karthick, T., & Sankaranarayanan, S. (2017). Intelligent IoT based water quality monitoring system. *International Journal of Applied Engineering Research*, *12*(16), 5447–5454.

Raj, J. R., Rahman, S. M. K., & Anand, S. (2016). Microcontroller USB interfacing with MATLAB GUI for low cost medical ultrasound scanners. *Engineering Science and Technology, an International Journal*, *19*(2), 964–969. https://doi.org/10.1016/j.jestch.2016.01.008

Varun, K. S., Kumar, K. A., Chowdary, V. R., & Raju, C. S. K. (2018). Water Level Management Using Ultrasonic Sensor(Automation). *International Journal of Computer Sciences and Engineering*, *6*(6), 799–804. https://doi.org/10.26438/ijcse/v6i6.799804

Vujović, V., & Maksimović, M. (2014). Raspberry Pi as a Wireless Sensor node: Performances and constraints. *2014 37th International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2014 - Proceedings*, (May), 1013–1018. https://doi.org/10.1109/MIPRO.2014.6859717

Sensor. In *The Merriam-Webster.com Dictionary*. Retrieved December 17, 2019, from https://www.merriam-webster.com/dictionary/sensor

Mohamed Farid Noh. *Pencemaran 'bunuh' Selat Johor*. Retrieved December 17, 2019, from https://www.bharian.com.my/berita/nasional/2019/07/585343/pencemaran-bunuh-selat-johor

Izlaily Hussein. *2.43 tonnes of chemical waste collected from Sungai Kim Kim on first day*. Retrieved December 17, 2019, from https://www.nst.com.my/news/nation/2019/03/469147/243-tonnes-chemical-waste-collected-sungai-kim-kim-first-day

Christina Nunez. *Water Pollution, explained*. Retrieved December 17, 2019, from https://www.nationalgeographic.com/environment/freshwater/pollution/

TechTip n.d., TechTip: Accuracy, Precision, Resolution, and Sensitivity, accessed 17 December 2019, https://www.mccdaq.com/TechTips/TechTip-1.aspx

Microprocessor and Microcontroller 2015., Difference Between Microprocessor and Microcontroller, accessed 17 December 2019, https://www.mccdaq.com/TechTips/TechTip-1.aspx

Arduino UNO from Wikipedia 2019., Arduino Uno, accessed 17 December 2019, https://upload.wikimedia.org/wikipedia/commons/3/38/Arduino_Uno_-_R3.jpg

wiki.dfrobot.com n.d., Gravity Analog TDS Sensor Meter For Arduino SKU SEN0244, accessed December 17, 2019, https://wiki.dfrobot.com/Gravity__Analog_TDS_Sensor___Meter_For_Arduino_SKU__SEN0244

EXISTEK. (2017). SDLC Models Explained: Agile, Waterfall, V-Shaped, Iterative, Spiral. Retrieved from EXISTEK: https://existek.com/blog/sdlc-models/

Margaret Rouse 2016., The evolution of data center storage architecture, accessed December 19, 2019, https://searchstorage.techtarget.com/definition/cloud-storage