An Automated Water Sprinkler Bot

by

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18001491

Dissertation submitted in partial fulfilment of

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Universiti Teknologi PETRONAS

32610 Seri Iskandar

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____

(DR SAID JADID A KADIR)

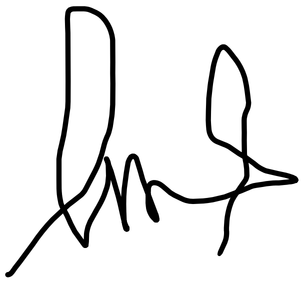
UNIVERSITI TEKNOLOGI PETRONAS

SERI ISKANDAR, PERAK

September 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



A’INI SA’ADAH BINTI OTHMAN

ABSTRACT

This report elaborates on the chosen research, which is to develop an Internet of Things (IoT) system that helps people watering their garden as well as check the pH level of the soil of the plant. Gardening is a practice of growing and cultivating plants as part of horticulture which people enjoy it as hobby or therapy. As technology continues to advance, various methods have been used to attempt to ease people in managing their garden which can maximize the growth of the plants. In this project, I will be creating an IoT system for irrigation and measure the pH of the soils using Raspberry Pi, microcontroller moisture soil, pump, pH meter of soil and pipe to create a prototype that can helps garden owner with packed schedule managing their garden.

In this report, I will begin by explaining the objectives, problem statement, scope, and significance of my project. I will then document my findings and knowledge gained from literature reviews and interview session with the expert from botanist field. Next, I will be explaining my methodology, which is prototype methodology to be specific in increment prototype model, the methodology that I will be following in the development of this project. A Gannt Chart that states the planned timeline of the report is also visualized. The final part of the report elaborates further on my conclusion of my findings along with the planned future work that I plan to conduct.

ACKNOWLEDGEMENT

Bismillahirahmanirahim,

Thanks to Allah SWT for providing me with the chance to accomplish my Final Year Project, which is titled An Automated Water Sprinkler Bot, as well as His Gracious for giving me health, knowledge, and time along this journey.

Firstly, I would like to express my gratitude to my Final Year Project supervisor, Dr Said Jadid A Kadir for his guidance and support along the process completing this project. Without his guidance throughout two semester sessions, I would not be able to complete this an automated water sprinkler bot project.

Deepest thanks to my family and friends for their help and encouragement for me to keep hustle with the project, especially in the middle of pandemic. Also, to all people who involve directly or indirectly for the guidance and advice throughout this project.

Thank you.

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ABBREVIATIONS AND NOMENCLATURES

ABBREVIATIONS

pH	Potential hydrogen
MCO	Movement Control Order
IoT	Internet of Things

NOMENCLATURES

Ca	Calcium
Mg	Magnesium
K	Kalium
Na	Sodium
CO_2	Carbon dioxide
H+	Hydrogen ion
Al3+	Aluminum ion

CHAPTER 1
INTRODUCTION

1.1 PROJECT BACKGROUND

Gardening is the activity of growing plants such as flowers, trees, or vegetables, and it can be done indoors or outdoors. This activity has been practiced in many places before century such as Greek, Middle East and Europe. For example, in Middle East gardening activities since 900 BC to 612 BC for food sources such as wine and to ensure the plant growth, they made pleasure gardens irrigated by water canals (Lambert, 2021). The practice being applied until today especially in managing, watering the plant and measure the pH meter of the soil.

During this pandemic, Malaysia government introduce Movement Control Order (MCO) as the responds to control the positive number of COVID19 in Malaysia. Due to this movement many sectors and workers are negatively impacted and number of people lost their job increase. In order to survive, some of them involve themselves in gardening or farming activities. This creates new opportunity for them to support themselves as well as to their family.

Besides that, gardening can be part of therapy especially during this pandemic. Online learning or work from home felt the pressure from limitation, workloads and communication difficulty. It can cause disturbance people physical and mentally. The feeling of satisfaction and time spending for gardening bring calm and peace to the gardener (Chalmin-Pui et al., 2021). It is gardening helps in managing the health of physically and mentally. Unfortunately, it hard for people who have packed schedule to manage their plant.

In addition, pH meter of soil is controlled by the leaching of basic cations like Ca, Mg, K, and Na far beyond their release from weathered minerals, leaving H+ and Al3+ ions as the dominant exchangeable cations; the dissolution of CO_2 in soil water produces carbonic acid, which dissociates and releases H+ ions (Neina, n.d.). Therefore, measured the pH of soil before making any decision to prevent the plant from withered (Muckel & Mausbach, 2015).

In this current day and age, along with the never-ending advancements of technology, new technology is being developed every day. Technology has helped us in countless ways, the travel industry, medical industry, improved our daily lifestyle, and provided us with tools that has helped us in our work and life that were unimaginable in the past. Naturally, researchers, technology and botanist professionals have started to look into the possibility of using technology in managing the garden more effectively especially in watering process.

The evaluation of an irrigation system began from the manual process and incorporated the micro-controller, wireless sensors and now it has reached the Internet of Things (IoT) based irrigation system. All these technologies are trying to manage the existing water and avoid wastage for irrigation.

1.2 PROBLEM STATEMENT

1.2.1 Lack of Exposure on Automated Irrigation System.

In Malaysia, most of gardener still water their plant manually than automated irrigation. Estimate that, 40 percent of fresh water used for agriculture in developing countries is lost through evapotranspiration, spills, or absorption by deep layers of soil beyond the reach of roots (Zhu et al., 2018). Compared to automated irrigation, only sufficient amount of water needed to water specific plant.

1.2.2 Difference Personal Preferences

Since gardening required close observation, the owner who have limitation to do it might seek helps from other people to manage it. This is where the personal preferences arise. Some people did not mind to have other people around their house and vice versa.

1.3 OBJECTIVES

For this project, listed here are the objectives that need to be achieved by the end of the project which are:

1. To investigate the existing work related to water systems.
2. To develop an IoT system prototype and mobile apps of the system as well as to conduct test on prototype and mobile apps.

1.4 SCOPE OF STUDY

As of all projects, this project needs a scope to explain the extent to which the research will be explored and also specify the parameters within the study will be operating. The scope of this project will be discussed below.

1. Malaysians

This project focused on Malaysian who have garden indoor or outdoor and have various plant either vegetables or flowers. In order to capture data on the watering system for each of different plants.

2. Limitation in Managing the Garden

People with packed schedule, always go on vacation or outstations or having any health issues. This is to ease our research project, allowing us to utilize our time and resources more efficiently by focusing on the main issue of the project.

CHAPTER 2
LITERATURE REVIEW

2.0 OVERVIEW

In this chapter, I will present a literature review on my topic area by reviewing, analysing, and evaluating previous studies.

2.1 GARDENING

2.1.1 DEFINITION

A garden is defined by dictionaries as an area of land near or adjacent to a house where plants, flowers, shrubs, trees, grass, and vegetables can be grown or cultivated. In the United States, the term "garden" usually refers to a vegetable garden, while "yard" (as in "backyard") refers to a flower or ornamental garden. In addition, gardens are also defined as parks or public recreation areas such as botanical gardens. Gardening is the job or activity of working in a garden and responsible to manage the plant to keep it attractive and includes the concept of gardening as a pastime or the work or art of a gardener (GROSS, 2013).

2.1.2 ADVANTAGES OF GARDENING

Gardening brings more benefits not only to ecosystems but also to human physically and mentally. As we grow older, the brain volume will be decrease approximately 5% per decade and this directly links to memory and brain functionality decline (Park et al., 2019). Alzheimer is one of example of memory decline, where usually it affecting senior citizen. This disease can be treated by improving the physical functionality ability, reduced blood pressure, immune system improved and many more and it can be done by doing aerobics activities such as gardening.

Gardening activities such as digging, raking, planting, weeding, watering, and harvesting are aerobics activities suitable for people of all ages. A study conducted to investigate the effect of horticultural therapy on demented old adults found that using horticultural therapy significantly improved cognitive function in dementia-stricken seniors. (Song, 2007 as cited in Park et al., 2019).

In addition, gardening also being use as horticultural therapy that help in with mental health especially during this pandemic. Since Movement Control Order (MCO) being introduce, number of people with mental health keep increasing. This may be due to the pressure from MCO. A study by shows that by gardening it help to decreased depressive symptoms, anxiety, sociability, and stress in depressed adults or children with intellectual disability by looking at the colour of the flower and the sense of pleasure when manage the garden (Kim et al., 2012).

As a result, gardening not only beautifies unused space, but also aids in the physical and emotional well-being of humans.

2.1.3 IRRIGATION SYSTEMS IN GARDENING

One of the most important aspects of gardening is water. Plants, like all living things, require a certain amount of water to survive. Estimated, 40 percent of fresh water used for agriculture in developing countries is lost through spills, evapotranspiration, or absorption by deep layers of soil beyond the reach of roots. Many freshwater resources have been degraded as a result of agricultural activity, including over-exploitation, nutrient contamination, and salinization (Zhu et al., 2018).

There are several factors that influence the plant's transpiration rate, including environmental factors and the plant itself. Environmental factors included humidity, temperature, soil, and wind, whereas plant factors included the plant's type. There is a stage in which plants may survive without water, which is known as dormancy; nevertheless, each plant has its own limitations for recovering when there is inadequate water during this phase. The incapacity of the plant to recover from moisture loss is referred to as the permanent wilting point. As a result, water is essential for the plant's survival (Raveendra Kumar Rai, Vijay P.Singh, 2017).

There are several ways that may be utilised in an irrigation system. Irrigation technologies utilised include drip irrigation, sprinkler systems, soaker hoses, and hand-held hoses. Among those examples, the most efficient irrigation technology and a cost-effective to save water is drip irrigation. Drip irrigation has a higher efficiency than other methods, such as sprinklers, which only have a 50 to 70 percent efficiency (Kruzhilin et al., 2018). Drip irrigation delivers water straight to the soil, significantly reducing loss due to evaporation. The primary advantage of drip irrigation is that it saves time and effort, which is very beneficial for busy gardeners.

Another technique is to use a water sprinkler, which is a rotating water hose that sprays water droplets over a large area (Kruzhilin et al., 2018). A sprinkler is beneficial for watering a newly laid grass, but it may be inefficient for a thorough soaking because the water evaporates rather than entering the ground. Another effective technique of watering the plants is with a soaker hose. It's similar to a drip, except instead of having an emitter at a set interval, the soaker hose has a small pore running the length of it.

Based on the approaches discussed above, we can infer that drip irrigation is mostly used in gardening.

2.1.4 THE IMPORTANT pH OF SOIL

Soil pH and organic matter have a significant impact. The plant nutrient availability and functions pH, in particular, affects the chemical solubility and availability of plant vital nutrients, pesticide effectiveness, and organic material decomposition. As we know, pH scale spans from 0 to 14 and distinguishes soil types with varied pH values across the world. For example, the pH of typical soil ranges from 3.5 to 9, in precipitation areas it runs from 5 to 7, and in dry regions it goes from 6.5 to 9 (Khan et al., 2021). As a result, understanding soil chemistry and the interacting variables that impact soil pH is critical for understanding plant nutrient availability and ideal growth conditions for various crops.

Soil pH is a measure of the acidity and alkalinity of the soil solution. pH is defined as the "negative logarithm of the hydrogen ion concentration [H+]," such as, pH = -log [H+]. Soils are classified as acidic, neutral, or alkaline (or basic) based on their pH values, which range from 0 to 14 (McCauley et al., 2009).

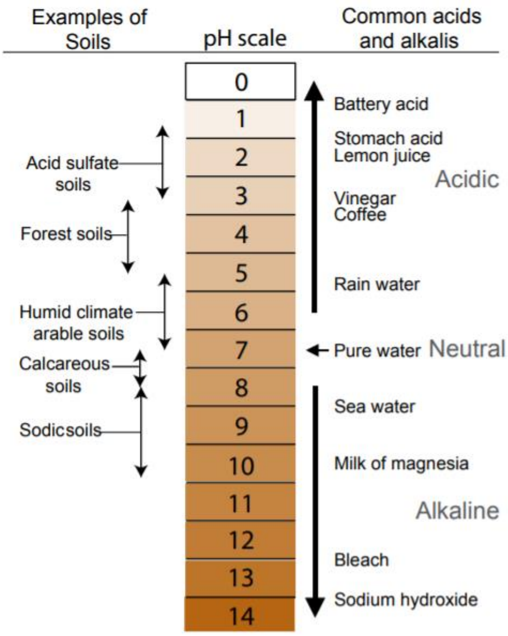

Figure 2. 1: The pH scale (From Soil pH and Organic Matter, 2009)

A pH of 7 is considered neutral (pure water), a pH less than 7 is considered acidic, and a pH more than 7 is considered alkaline. Since pH is a logarithmic function, each unit on the pH scale is 10 times more alkaline (less acidic) than the unit below it (McCauley et al., 2009). A solution with a pH of 6 contains ten times the concentration of H+ ions as a solution with a pH of 7, and one hundred times the concentration as a solution with a pH of 8.

Acid and base-forming ions in the soil both impact soil pH. Hydrogen (H+), aluminium (Al3+), and iron (Fe2+ or Fe3+) are frequent acid-forming cations, whereas calcium (Ca2+), magnesium (Mg2+), potassium (K+), and sodium (Na+) are typical base-forming cations (McCauley et al., 2009).

Plants primarily take nutrients from the soil. This demonstrates that soil pH has a significant impact on nutrient levels. With the exception of P, which is most accessible at pH 6 to 7, macronutrients (N, K, Ca, Mg, and S) are more available at pH 6.5 to 8, whereas the majority of micronutrients (B, Cu, Fe, Mn, Ni, and Zn) are more available at pH 5 to 7 (McCauley et al., 2009). Nutrients are accessible to plants in lower concentrations outside of these optimum limits.

Since plants require both water and nutrients from the soil or fertiliser, it is critical to monitor the nutrient availability in soils by testing the pH level of the soil. As a result, test the pH of the soil before making any decisions to save the plant from wilting (Muckel & Mausbach, 2015).

2.2 SMART HOME

2.2.1 SMART HOME

A smart house is a technology that automates the home's occupants, sometimes known as an automated home system. The smart house is at the centre of technology that every home should have today. For example, several studies emphasise the importance of smart home technology in reaching “net energy buildings,” “zero energy buildings,” and “life cycle zero energy buildings” (Sovacool & Furszyfer Del Rio, 2020).

A smart home consists of with three major components: sensors, controllers, and actuators; controllers are instruments used for transmitting and receiving signals on PCs, tablets, or smartphones regarding the status of automated gadget operations and features at home (Markets, 2021). Most advanced nations have largely embraced a home automation system to enhance the efficiency of their homes. However, in a developing nation such as Malaysia, the market for home automation systems is still in its early stages especially on smart irrigation for garden.

As a result, smart irrigation should be pushed more in Malaysia since it makes it easier for people to manage their gardens.

2.2.2 SMART IRRIGATION

As previously stated, another use of an automated system is the irrigation system. Some home automation systems incorporate a smart irrigation system as part of their system, which is especially useful for homes with a lawn or garden. Regardless of its use, smart irrigation systems are becoming increasingly crucial in ensuring the most efficient use of water, particularly in agriculture, where water supplies are limited (Livesley et al., 2021).

As technology advances, a variety of smart irrigation systems have been proposed, either for the agriculture industry or for small-scale application, like as at home. For this project, a few irrigation systems that take a different approach were studied to see what they had in common and where they differed. Although the system was primarily intended for agriculture, the principle remains the same and the method may be used to a smaller size project such as a home garden.

A smart irrigation system is one that saves water by monitoring and utilising information about site conditions such as soil moisture, rain, wind, and more, and then applying those factors to apply the appropriate quantity of water. According to the Environmental Protection Agency (EPA), replacing the traditional clock timer controller used in most yards with one of its certified "smart" irrigation controllers may save an average home about 8,800 gallons of water each year (CROTTA, 2014). This due to, the water at a slower pace than typical sprinkler heads for improved soil penetration, reduced runoff, and water savings of up to 30% (CROTTA, 2014).

A conventional irrigation system frequently employs a timer to automate the watering period, and the system rarely adjusts to variations in weather or humidity. This conventional irrigation technique, however, causes an issue since the plant gets watered at regular intervals regardless of the weather or soil condition. The system is not well adapted to the plant's various water requirements, which might result in the plant receiving too much water in the winter or being under-irrigated in the summer (Abbas et al., 2014).

CHAPTER 3
METHODOLOGY

3.0 OVERVIEW

The approach utilised for this project will be discussed in depth in this chapter, from the research phase through the project's conclusion. This chapter will include the following sections: Research Methodology, Development of Project and Tools, System Architecture, Gantt Chart, and Project Milestones.

I will discuss how I conduct my research for this topic under research technique. Under Project Development, I will describe the data science project structure that I utilised in this project. Following that, in the section on development tools, I will go over the tools I used to create this project. Finally, I will visualize the timeframe using a Gantt Chart and the milestones of the project.

3.1 RESEARCH METHODOLOGY

3.1.1 Preliminary Investigation

Before I start working on this project, I need to perform some preliminary research so that I can grasp the foundations of it, see what other people have done, and figure out what essential aspects will help me succeed. To perform my preliminary study throughout this phase, I will use two (2) methods: literature review and interviews.

Literature Review

There is a lot of material and relevant previous works on the internet, which is why a literature study is essential. Existing papers, writings, and other verifiable sources include material that would give insights into my study since they contain thorough analysis, assessment, investigations, and synthesis performed by past scholars.

These papers and literature are widely accessible on the internet through services like Google Scholar, IEEE, and Science Direct, which hold published articles. To synthesise an analysis for my project literature review, other sources such as electronic books and journals may also be employed as literature review materials.

The knowledge and insights acquired from these literature studies provide a comprehensive grasp of current existing models as well as other relevant initiatives. I was able to properly understand what is necessary to do this project, as well as a solid guidance on how to conduct this project, with a clear comprehension.

Interviews

Interviews were the next approach utilised for preliminary research. As a student, my understanding of gardening is extremely limited, therefore conducting interviews with specialists in the area may be a very simple approach to get insights into the subject. My aim for the interview session is to learn about the main aspects in garden management, particularly watering and monitoring the pH level of the soil.

I interviewed an expert for this preliminary inquiry interview phase. A person who is well-versed in the subject of botany. The person I spoke with is a supplier of chilies to Nestle, who owns around a hectares of chilies farm. Following a conversation with him, he agreed that proper plant watering practises are critical to ensuring good development. He also mentioned that not many people are aware of the need of monitoring soil pH because key nutrients from plants are gained from soil.

3.2 DEVELOPMENT OF PROJECT AND TOOLS

The system will be developed using an incremental model for this project. The incremental model employs the same basic software development process, which includes gathering requirements, designing, coding, and testing (Sami, 2012). The end product is constructed as a series of prototypes. In the end, the many prototypes are combined into a single design (Sami, 2012).

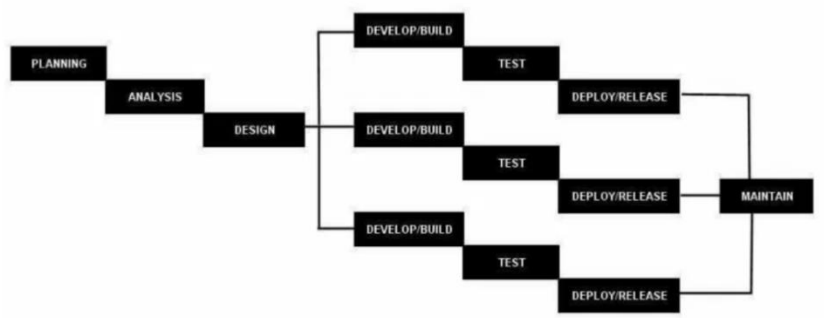

Figure 3. 1: Incremental model

The main product comprises the majority of the functionality. The initial increment may be provided to the user as the first release, and further functionality and features will be created as releases 2, 3, and so on. For this project, the system is divided into different functionalities and placed in increment. The project's planning progress is seen below:

Table 3. 1: Project incremental model

Increment level	**Functionality**
Increment 1	Setting up a ESP32 for input and output devices such as a soil humidity sensor and a water drop for a sprinkler system, as well as a pH sensor for soil pH level detection.
Increment 2	Setting up the server.
Increment 3	Testing the prototype.

Since an automated sprinkler and pH level detection as the for this project, it was the first to be assemble. Finally, a server is built so that the user may control the water sprinkler and display the soil pH level.

In this project, I will create an automated sprinkler bot that will aid in watering and measuring the pH of the soil. As of today, numerous studies have been conducted on automated sprinklers, but yet research has been conducted on both automated watering and soil pH measurement. Therefore, below are the project tools needed for this project.

Hardware required in this project are:

Table 3. 2: List of hardware component

Name	**Uses**
ESP32  Figure 3.2: ESP32	Wi-Fi module that reads capacity and able to act as microcontroller.
Relay  Figure 3.3: Relay	To close or open the pump circuit after signal are received.
Capacitive Soil Moisture Sensors	To determine the moisture content of the soil. Capacitive sensors are not soluble.

 Figure 3.4: Capacitive soil moisture sensors	
Pump  Figure 3.5: Pump	This pump is powered by a separate power supply and is controlled by a relay.
Aquarium tube and irrigation nozzles  Figure 3.6: Aquarium tube and irrigation nozzles	Water transfer to the plants and to distribute the water to the plant.
pH Meter sensor components  Figure 3.7: pH meter sensor components	Build in with ATC (auto temperature compensation), that has a wide range of applications in soil and water monitoring, including agriculture, gardening, horticulture and more.

3.3 SYSTEM ARCHITECTURE

As mentioned previously, there is yet any study on IoT system of smart irrigation with pH meter. As for now, I decide to separate the automated sprinkler and the pH meter, since my knowledge in wiring and connecting all the component are limited and need further research.

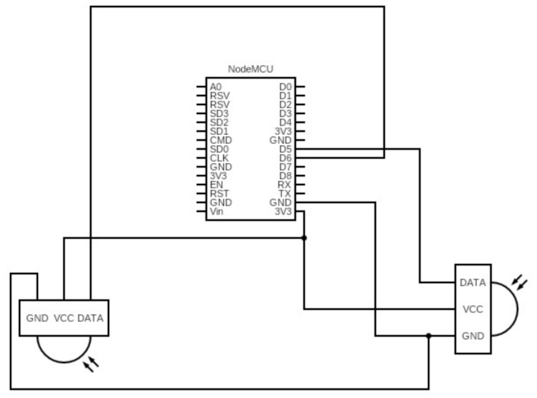

Figure 3.8: Circuit of an automated water sprinkler.

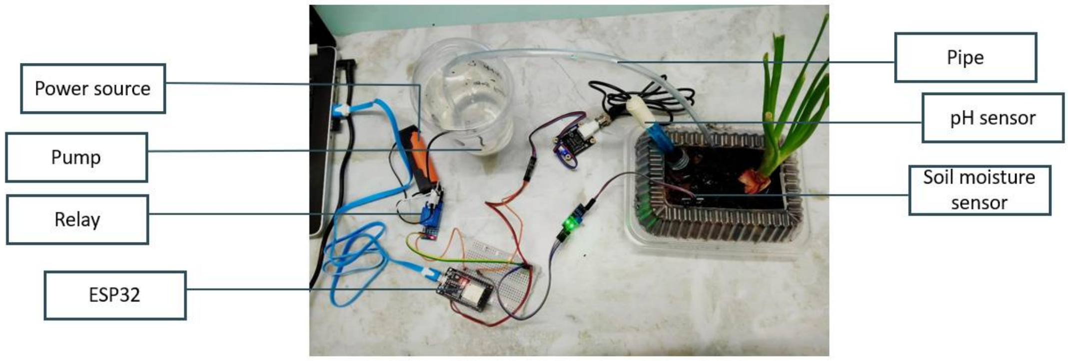

Figure 3.9: Hardware setup.

To monitor soil moisture, the ESP32 microcontrollers read the analogue signals from the capacitive sensors. From the figure above soil moisture sensor connected to pin D6 while pH meter sensor connected to pin D5. These 2 pins will capture the data and user will decide whether or not the sensor's relay should be activated. When the switch is turned on, the circuit to the pump is closed, and the plants are watered, while for pH metre sensor the data was capture by simply read the pH value.

The architecture was chosen since it able to combine two sensors in one microcontroller since it has 15 analog-to-digital converter (ADC) pins that use to read the analogue input. In addition, ESP32 able to connect to Bluetooth and Wi-Fi since it was built within it. Thus, it much easier to connect to user devices to handle this an automated water sprinkler.

3.4 GANNT CHART

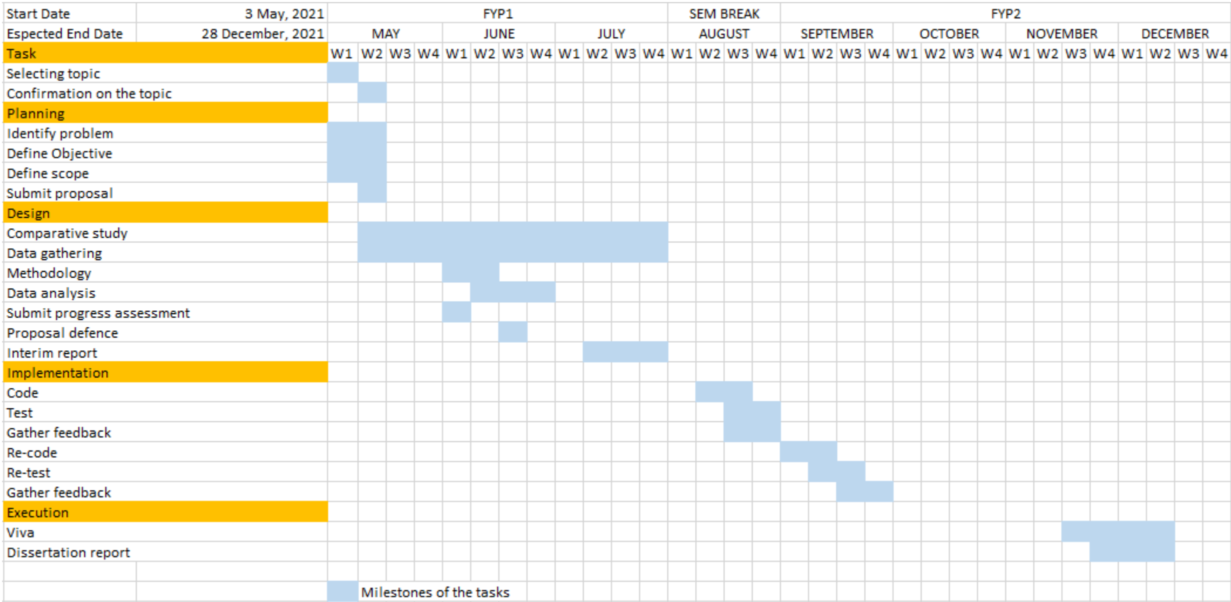

Figure 3.10: Gannt chart of the project

CHAPTER 4
RESULTS AND DISCUSSION

As stated, the objectives of this project are to investigate the existing work related to water irrigation as well as developing IoT system for it. Therefore, in this chapter it will explain more on the objectives as well as the development of the project.

4.1 Driving Factors

Some researchers are made, below are several factors can be considered for this project.

1. Plantation factors
   a. Type of the garden

      Since pandemic outbreaks, numbers of Malaysian involved in gardening. Due to the limited number of space and land, urban farming as a solution for it (DEWI, 2020). Urban farming is a practice of growing or maximizing food source in one place (*WHAT IS URBAN FARMING?*, n.d.). What they usually do is either planted the plant in container or in-ground garden. In ground garden is a process of people planting directly on the ground. There also hydroponic gardening where it is a technique of planting without soil (Woodard, 2019). This project focus design on urban garden that plant in container.

   b. Type of plant

      Every type of plant has their own watering method, where it can give impact to their growth. In order to transport all nutrient that receive from roots to leaves, plant need water as transportation medium. Without enough water, plant will be withered which can lead to die

(Armstrong, 2021). For example, succulent and cactus only required to be water once or twice a week, compared to vegetables and fruits, it must be water twice a day. The project able to set irrigation system based on the type of plant.

c. pH of soil

pH of soil also impacts the growth of the plant as same as amount of water needed for a plant. pH can be acidic, neutral, or alkaline. Suitable pH for plant is in range of 6.0 to 7.0, but some plant like blueberries required acidic soil than neutral (Boeckmann, 2019). Therefore, this project also measures pH level of soil to ensure the plant receive all nutrient throughout its development.

d. Watering method

There are few watering methods that being use to water the plant according to the type plant and size of the garden. The most commonly watering method that being use by gardener are drip and sprinkler method (Chinn, n.d.). Both methods can be used for any type of plant but for large area, more suitable for sprinkler than drip (Chinn, n.d.). Since, in this project focus on container planting, drip irrigation more suitable.

2. Hardware and software

ESP32 is a microcontroller that built in with Wi-Fi and Bluetooth together, plus it cheap and contains good number of general-purpose input/output (GPIO) pins that can be use in many types of IoT projects (*ESP32 - DevKitC*, 2020). Besides that, there are two sensors being use in this project, which are soil moisture sensor and pH sensor. Soil moisture sensor use to measure the existing of water in the soil while pH sensor uses to measure pH of soil. The attribute of ESP32 make it suitable to be use for this project.

This project using Arduino IDE, Cloud Firestore by Firebase and Ionic to develop an automated water sprinkler bot. Arduino IDE is an open-source Integrated Development Environment (IDE) is use to write and upload the code into the microcontroller. In this project, the microcontroller is ESP32.

To manage and store the data from the sensors, this project stores the data in cloud by using Firebase product known as Cloud Firestore. This software is a flexible and able to synchronized the data across user application through real-time listeners and offer offline support for mobile and web (*Cloud Firestore*, 2021). By that, the project can be developed which it works regardless of network expectancy or internet connectivity (*Cloud Firestore*, 2021).

The last software being use is Ionic to developed the interface of the system. An Ionic is an open-source of software development kit (SDK), that use to hybrid the mobile application development (*Browser Support*, 2020). This software also allows the user to build any application and it can be customized for various operating system such as Android, iOS, Windows and many more (*Browser Support*, 2020).

4.2 Setting up the components

The first thing to do is to install the microcontroller into Arduino IDE. It can be done by download and open the Arduino IDE in the desktop. The latest version of Arduino IDE software can be installed from https://www.arduino.cc/en/software.

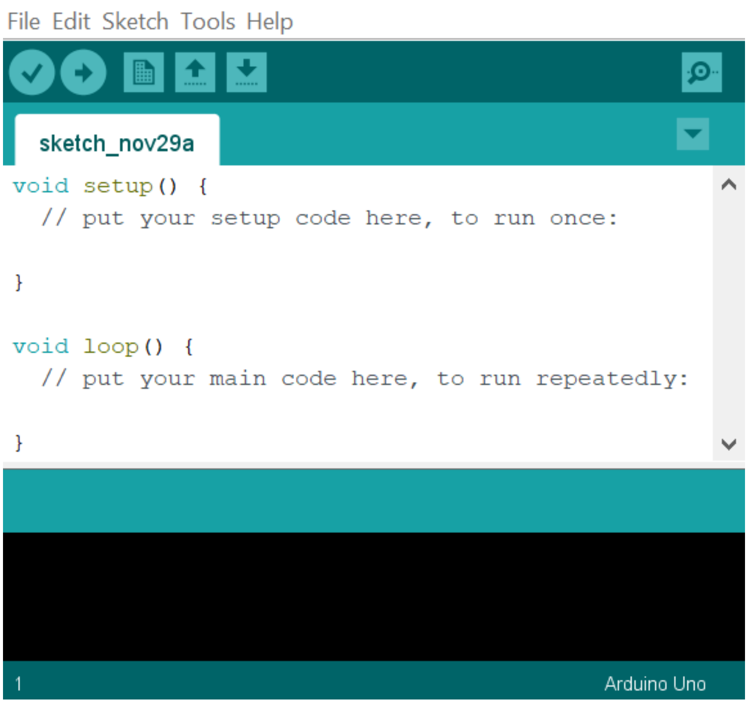

Figure 4.1: Arduino IDE environment.

Then, go to File tab > Preferences.

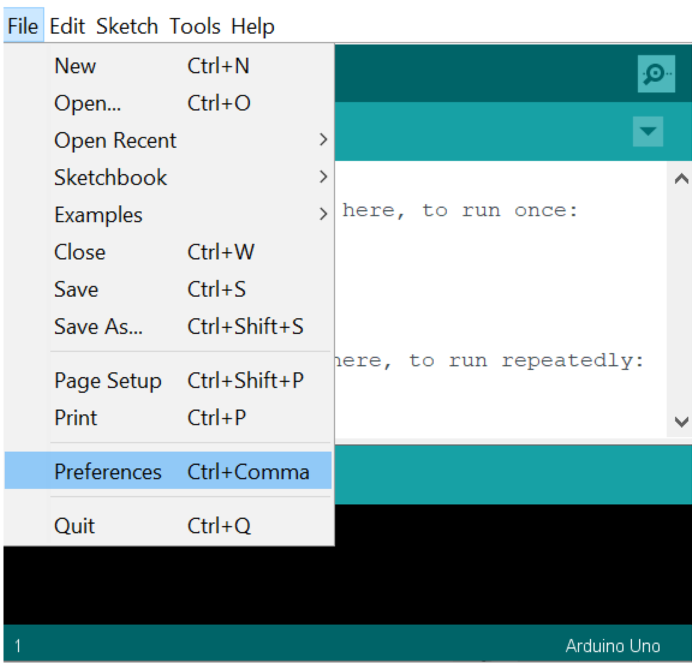

Figure 4.2: Installing ESP32 in Arduino IDE

The next step is pasting this link https://dl.espressif.com/dl/package_esp32_index.json into "Additional Board Manager URLs" and click OK.

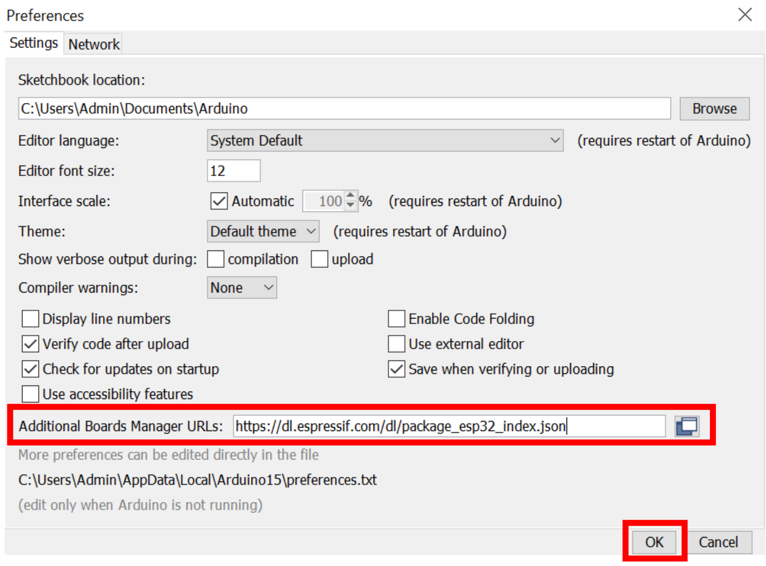

Figure 4.3: Interface of Additional Board Manager URLs.

Next, open the Boards Manager and go to Tools tab > Board > Boards Manager…

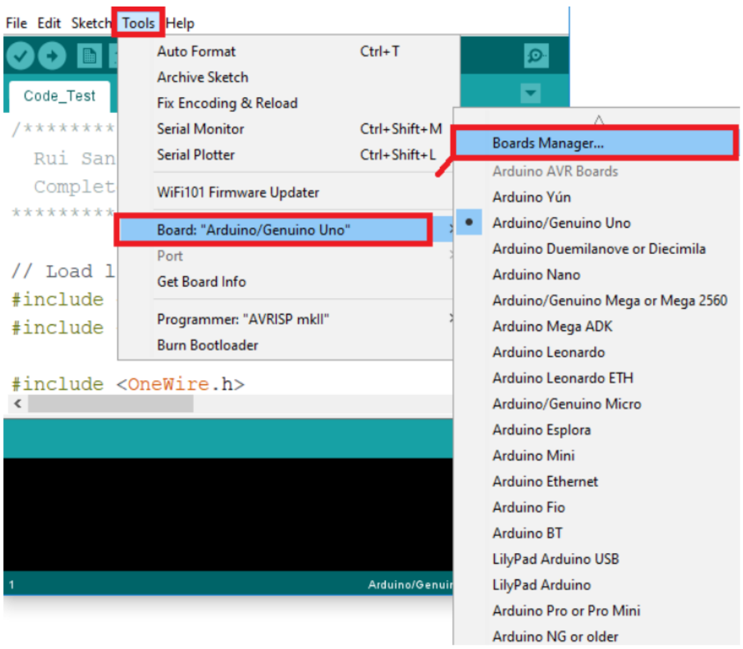

Figure 4.4: Interface of board Manager.

Lastly, search for ESP32 and installed it. After a moment, microcontroller ESP32 were installed in Arduino IDE.

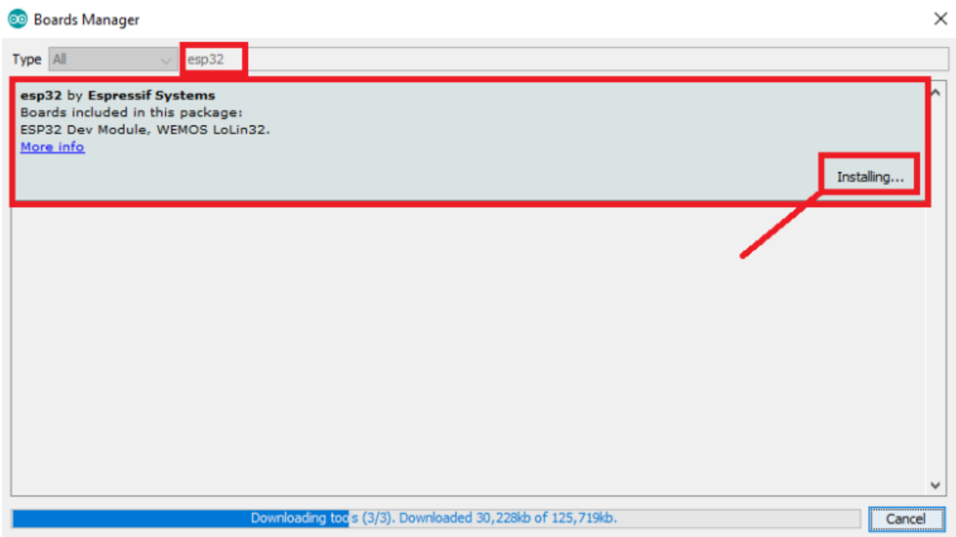

Figure 4.5: Interface of ESP32 installation.

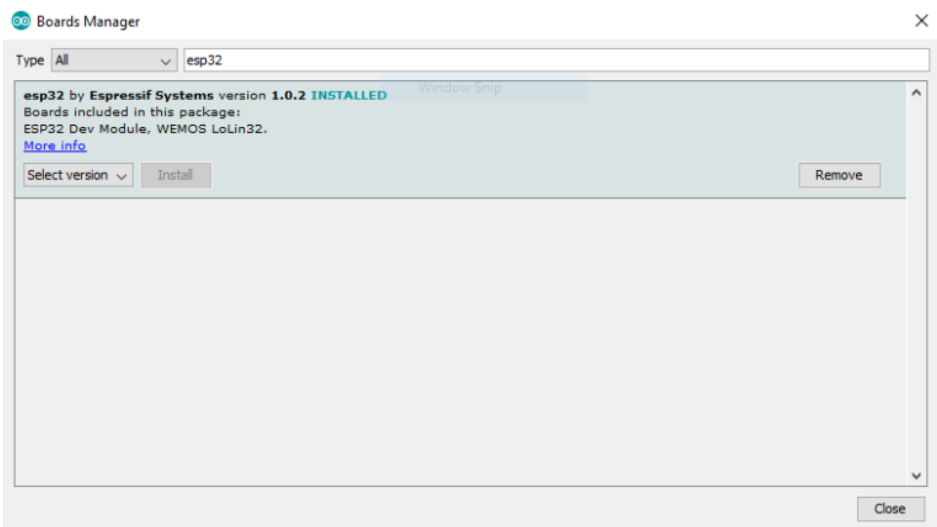

Figure 4.6: ESP32 installed in Arduino IDE.

After complete the installation of the ESP32, the next process is to set up the whole components. To set up the circuit, a consultation was made with an expert in handling IoT project. In the microcontroller of ESP32, there are two analog pins that able to connect the two sensors in one microcontroller. To connect the pump, a relay is used because the pump require a high voltage and it is likely used more power than the ESP32 digital output can directly draw. If it's directly connected with the digital output of ESP32, there is a possibility that it will damage the board. Therefore, a relay is used to enable the low power component (ESP32) to control high power components (water pump). For pH meter, it will display the pH value that generate from the small differences between the output of one electrode and another electrode.

To ensure the pH meter sensor shows the correct value is, by let the pH meter sensor stay in the solution for a moment until it displays the same output (*PH Meter*, 2018).

Figure 4.7: The setup of the components.

4.3 Programme the components using Arduino IDE

In Arduino IDE, there are four mains need to be defined before continue with the functionalities and data management. The four mains are:

1. Define the Wi-Fi credentials.
2. Define Firebase host name and the API Key.
3. Define Firebase project ID.
4. Define the user e-mail and password.

```
// the setup routine runs once when you press reset:
#if defined(ESP32)
#include <WiFi.h>
#elif defined(ESP8266)
#include <ESP8266WiFi.h>
#endif
#include <Firebase_ESP_Client.h>

/* 1. Define the WiFi credentials */
#define WIFI_SSID "WIFI_AP"
#define WIFI_PASSWORD "WIFI_PASSWORD"

/* 2. Define the Firebase project host name and API Key */
#define FIREBASE_HOST "PROJECT_ID.firebaseio.com"
#define API_KEY "API_KEY"

/* 3. Define the project ID */
#define FIREBASE_PROJECT_ID "PROJECT_ID"

/* 4. Define the user Email and password that alreadey registerd or added in the project */
#define USER_EMAIL "USER_EMAIL"
#define USER_PASSWORD "USER_PASSWORD"
```

Figure 4.8: Setup and define the main components in Arduino IDE.

The next step is, define the data of the object in Firebase. This step is used to assign the data of user information such as Wi-Fi, the project host and the API key as well as the user sign in.

```
//Define Firebase Data object
FirebaseData fbdo;

FirebaseAuth auth;
FirebaseConfig config;

unsigned long dataMillis = 0;
int count = 0;

void setup()
{

    Serial.begin(115200);

    WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
    Serial.print("Connecting to Wi-Fi");
    while (WiFi.status() != WL_CONNECTED)
    {
        Serial.print(".");
        delay(300);
    }
    Serial.println();
    Serial.print("Connected with IP: ");
    Serial.println(WiFi.localIP());
    Serial.println();
```

```
    /* Assign the project host and api key (required) */
    config.host = FIREBASE_HOST;
    config.api_key = API_KEY;

    /* Assign the user sign in credentials */
    auth.user.email = USER_EMAIL;
    auth.user.password = USER_PASSWORD;

    Firebase.begin(&config, &auth);
    Firebase.reconnectWiFi(true);

#if defined(ESP8266)
    //Set the size of WiFi rx/tx buffers in the case where we want to
    //work with large data.
    fbdo.setBSSLBufferSize(1024, 1024);
#endif


}
```

Figure 4.9: Firebase setup to manage the data.

The final step is to code on functionalities which are read and display the soil moisture level and pH meter level.

```
void loop()
{
 int ph = analogRead(phpin);
   int soil = analogRead(soilpin);

   if (millis() - dataMillis > 60000 || dataMillis == 0)
   {
       dataMillis = millis();

       String content;
       FirebaseJson js;

       String documentPath = "Devices/sensor1";

       count++;

       js.set("fields/ph/integerValue", String(ph).c_str());
       js.set("fields/soil/booleanValue", String(soil).c_str();
       js.toString(content);

       Serial.println("------------------------------------");
       Serial.println("Update a document...");


       /** if updateMask contains the field name that exists in the remote document and
        * this field name does not exist in the document (content), that field will be delete from remote document
       */

       if (Firebase.Firestore.patchDocument(&fbdo, FIREBASE_PROJECT_ID, "" /* databaseId can be (default) or empty */,
       documentPath.c_str(), content.c_str(), "ph,soil" /* updateMask */))
       {
           Serial.println("PASSED");
           Serial.println("------------------------------------");
           Serial.println(fbdo.payload());
           Serial.println("------------------------------------");
           Serial.println();
       }
       else
       {
           Serial.println("FAILED");
           Serial.println("REASON: " + fbdo.errorReason());
           Serial.println("------------------------------------");
           Serial.println();
       }
   }
}
```

Figure 4.10: Setup the functionalities of both sensors.

4.4 Testing the prototype

There are two parts for testing prototype phase. The first part is testing the soil moisture sensor and the other testing is on the pH meter sensor.

1. Soil moisture sensor.

   When the soil moisture sensor where place in the dry soil or out of water, the water pump is on and pump out the water.

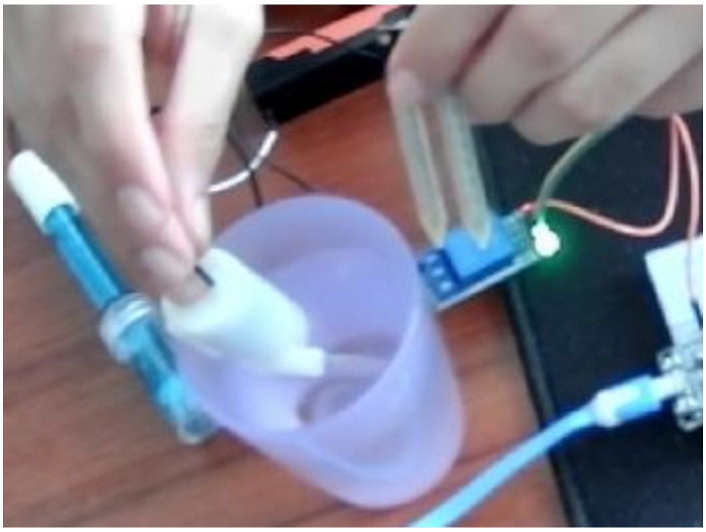

Figure 4.11: Place the soil moisture sensor out of the water.

Figure 4.12: The user interface when the soil moisture out of the water.

In the user interface, it shows the value of pH value, soil moisture value, the mode either to control automatically or manually and the action of the pump. As in the figure 4.12, the mode of the control is auto and the soil moisture shows 1% which indicate that the soil is dry, directly the pump is on.

When the soil moisture place in the water, the pump will automatically stop. Since it more than 10%, it reaches the moisture level.

Figure 4.13: The soil moisture place in the water.

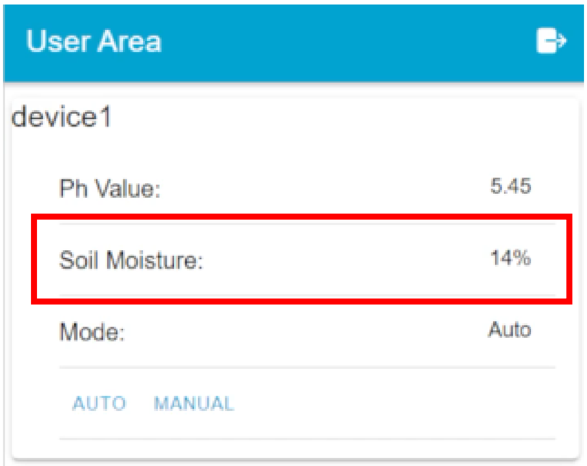

Figure 4.14: The user interface after place the soil moisture in the water.

2. pH meter sensor.

For pH meter sensor, it uses to measure the pH level of the soil. As for testing, the pH meter sensor was place in the water to test either the pH meter can measure the value of water or not. As we know, the value of water is neutral which is pH 7.

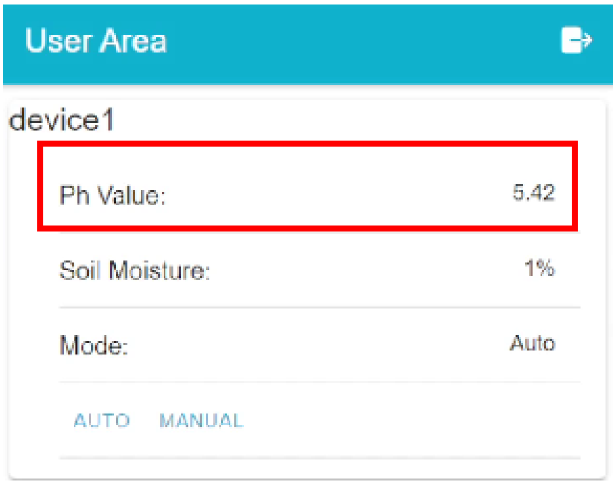

Figure 4.15: The pH value before place the pH meter sensor into the water.

Figure 4.16: Place the pH meter sensor into the water.

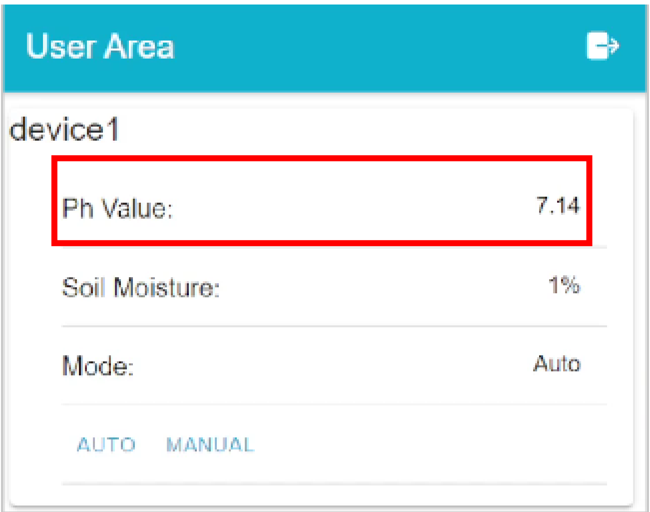

Figure 4.17: The pH value after measure the pH of water.

To check either it can read other pH level is by put the pH sensor into the buffer solution. Here, the pH meter sensor was put into buffer solution pf pH 4.0 or acidic level.

Figure 4.18: Place the pH meter sensor into buffer solution.

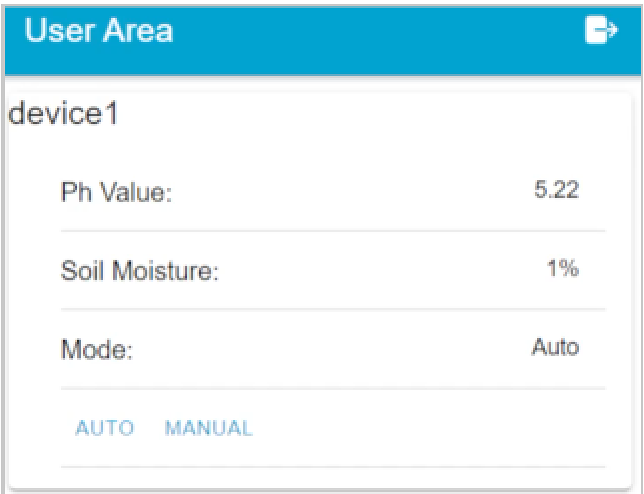

Figure 4.19: The output of the testing.

The output of the testing is 5.22, a bit above than 4.0 but it still in the range of acidic.

4.5 Discussion

In this project, there are few changes are made on the components. At first, I want to use Raspberry Pi and ESP8266 as microcontroller and Wi-Fi adapter for this project. After consult with my friend who expert in IoT project, he suggests to use only ESP32 since it can act as both microcontroller and Wi-Fi adapter. In addition, ESP32 has two analogue pin that can connect to both sensor while for ESP8266 only have one analogue pin. Therefore, I change the microcontroller to ESP32.

During the testing of prototype, pH meter sensor could not read any value as it gives the result of zero throughout the testing. From the research and consult with my friend, he gives me to lend his pH sensor. Right after change it, the pH sensor able to read the buffer solutions.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In conclusion, appropriate watering methods and soil pH monitoring are critical to ensuring plant development. Although, as of today, many types of water sprinklers or smart irrigation are available to assist in the automatic watering of the garden. However, there are products that both irrigate the plants and check the soil pH.

Researchers and botanists have discovered a technique to assist gardeners in maintaining their gardens by employing IoT systems, thanks to technological developments. Despite the fact that IoT solutions have been created to make garden management more efficient. There are also fewer gardeners that use IoT technologies to make better use of their gardens.

This project attempts to solve the concerns raised above. By the end of the project, an IoT system that can automate watering and monitor soil pH level will be constructed.

As part of the project's preliminary investigations, literature reviews and interviews were conducted to learn more about prior researchers and papers. I learned more about plant anatomy and the reasons that may cause a plant to die as a result of the interviews. With that knowledge, I was able to concentrate my efforts on the correct variables, focusing on the most essential aspects in the development of the systems.

5.2 RECOMMENDATION

This project has its own potential for improvement and adaptation. Therefore, there are several suggestions of recommendation would like to be proposed as part of future work.

1. Creating the project for large scale plantation.

   This project is good for plantation since it eases us in managing the plant, especially for large scale plantation. For large scale plantation, the already use water sprinkler to water the plant by setting the timer. This method good, but having soil moisture sensor able to automate the water sprinkler whenever the soil is dry and it helps to maximize the production of the plant since having too much of moisture have high tendency for plant to die. It also saves the water since it only water the plant in need.

2. Automation on water supply.

   In this project, the water supply is stored in the container and must be refill when the water is used. This required user for frequently check the water supply. For the improvement, it can be great to have reminder to the user whenever the water storage is low. This can be applied for small scale of plantation, but for large scale of plantation, having a powerful pump from water sources is great as the water supply.

3. Add more sensor features.

   To improve the monitoring process on the plant condition, there are more sensor can be added on. Having a forecast weather able to alert user to monitoring their plant especially for outdoor plant. In addition, in future might be have a camera feed to observe the condition on the plant such as checking the discolouration on the leaves.

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APPENDICES

Interview question and answer.

Question	:	What is the average water intake need by plant for them to growth?
Answer	:	It depends on type and size of plant itself. Different plant, different water intake. To say average water intake for plant, it is about 0.016 to 0.193 kg/day.
Question	:	What is the best method to water the plant?
Answer	:	There are few methods of watering the plants. The important rule to water the plant is to know when to water it. The best time to water the plant is in the morning, before evaporation process occur. For the type of irrigation, I would suggest drip irrigation because it is water direct to the water over the entire plant. Sprinkler irrigation is also suitable for a large area of plantation. It will cover all the areas of the plant as well as minimal labour for watering them.
Question	:	Does measuring pH level of soil for a plant important?
Answer	:	It is important, since the availability of most all essential plant nutrients is determined by pH, which is necessary for plant growth. The highest quantity of nutrients is accessible for plant usage with a pH of 6.5.

Question : If we planted our plant at soil with pH more or lower than the average soil pH, will it slow down the growth of the plant?

Answer : Yes, the growth rate become slower but it does not affect the fertility of the plant. When pH is high, the nutrients become less soluble. So, the time for nutrient to be delivered from root getting longer. That why the growth of the plant become slower.

Question : Do you think this project is good enough for plant or gardening activities?

Answer : I personally think that this project is good since there are yet to see a technology that highlight more on plant needed other than irrigation or watering. Your project has the add on function such as pH meter to sense the pH level of soil. It is interesting to be further develop with more add on function that relate to this focus.

Question : In your opinion, which part can be further developed from this project?

Answer : What can I see is that, this project can be further develop in certain aspect such as temperature control or light-emitting diode control for better protection from the exposure of UVR by sunlight.