IOT BASED DETECTION OF HARM MERCURY SUBSTANCE IN COSMETICS

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
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DECLARATION

I declare that "IoT Based Detection of Harm Mercury Substance in Cosmetics" is the result of my own work except for quotes as cited in the references.

Signature : ....

Author : ALBERT TIONG GUO LEE

Date : ....07 JAN 2022.................

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ....

Supervisor Name : ....

Date : 10 JAN 2022 ....

DEDICATION

I would like to dedicate the success of this project research especially to my parents which are my father Tiong Hua Choung and my mother, Ling Chai Hee. This report will be dedicated to them because I want to thank that for all the sacrifices that they made for me while I have been studying at this university. Secondly, this dedication is given to my siblings who have helped in terms of advice, finance, and encouragement support to make this report. Next, I would like to express a lot of gratitude to my supervisor, Dr. Anis Suhaila binti Mohd Zain, and my friends that give me a lot of help while completing this Final YearProject.

ABSTRACT

Heavy mercury is one of the most toxic substances that can cause serious health effects including kidney damage, anxiety depression, and memory loss. Mercury-containing cosmetics have been used as skin bleaching agents without considering the clinical effects. The objective of this project is to develop IoT Based mercury substance detector in cosmetic products. The scope of the project is to find a suitable sensor, determine the detection value range of mercury in cosmetics, and build a circuit to send data through IoT. The software used in this project are Arduino IDE, Blynk, and Google Spreadsheet. Arduino IDE is used to develop the coding of NodeMCU. Blynk and Google Spreadsheet are used to receive data from NodeMCU. The main components used in this project are NodeMCU Board, pH sensor, and connecting wire. The pH sensor is connected to the NodeMCU board through a connecting wire. Through the code developed by the Arduino IDE, the data from the pH sensor will notify the Blynk software of the presence of mercury through the NodeMCU board. The detection data of the pH sensor will also be stored in the Google spreadsheet, and the historical detect data of the project can be viewed through the Google spreadsheet.Among the five cosmetic samples analyzed, only the pH values (pH 6 and 6.2) of two samples were detected in the presence of harmful mercury substances. In conclusion, IoT Based mercury substance detector in cosmetic products has been developed and can be viewed through Blynk software and Google spreadsheets.

ABSTRAK

Merkuri berat adalah salah satu bahan paling toksik yang boleh menyebabkan kesan kesihatan yang serius termasuk kerosakan buah pinggang, kemurungan kebimbangan dan kehilangan ingatan. Kosmetik yang mengandungi merkuri telah digunakan sebagai agen peluntur kulit tanpa mengambil kira kesan klinikal. Objektif projek ini adalah untuk membangunkan pengesan bahan merkuri Berasaskan IoT dalam produk kosmetik. Skop projek adalah untuk mencari penderia yang sesuai, menentukan julat nilai pengesanan merkuri dalam kosmetik, dan membina litar untuk menghantar data melalui IoT. Perisian yang digunakan dalam projek ini ialah Arduino IDE, Blynk, dan Google Spreadsheet. Arduino IDE digunakan untuk membangunkan pengekodan NodeMCU. Blynk dan Google Spreadsheet digunakan untuk menerima data daripada NodeMCU. Komponen utama yang digunakan dalam projek ini ialah Papan NodeMCU, sensor pH, dan wayar penyambung. Penderia pH disambungkan ke papan NodeMCU melalui wayar penyambung. Melalui kod yang dibangunkan oleh Arduino IDE, data daripada sensor pH akan memberitahu perisian Blynk tentang kehadiran merkuri melalui papan NodeMCU. Data pengesanan penderia pH juga akan disimpan dalam hamparan Google dan data pengesanan sejarah projek itu boleh dilihat melalui hamparan Google. Antara lima sampel kosmetik yang dianalisis, hanya nilai pH (pH 6 dan 6.2) dua sampel dikesan dengan kehadiran bahan merkuri berbahaya. Kesimpulannya, pengesan bahan merkuri Berasaskan IoT dalam produk kosmetik telah dibangunkan dan boleh dilihat melalui perisian Blynk dan hamparan Google.

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First of all, I'm praise Jesus for giving me the time, healthy life, and opportunity to complete this research project titled "IoT Based Detection of Harm Mercury Substance in Cosmetics" fulfill the compulsory requirements of Universiti Teknikal Malaysia Melaka (UTEM) and the Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer (FKEKK). I really appreciate this opportunity to express gratefulness to those who made this project become possible.

In addition, I want to give a big thanks to my supervisor Dr. Anis Suhaila Binti Mohd Zain (FRGS/1/2020/FKEKK-CETRI/F00429) that gives a lot of guidance during semester 2 in session 2020/2021 on her knowledge expertise, suggestion, and useful comment while completing this research project. Next, a great of appreciatively to my panels of this research project which is Dr. Faiz Bin Arith and Siti Amaniah Binti Mohd Chachuli for their guidance and knowledge about this research.

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LIST OF ABBREVIATIONS

AAS Atomic Absorption Spectroscopy.

Al2O3 Passivation layer.

AuNPs gold nanoparticles.

CVAAS Cold Vapor Atomic Absorption Spectrometry.

DO 3.3V pH limit trigger.

FET Field Effect transistors.

FKEKK Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer.

GFAAS Graphite Furnace Atomic Absorption Spectroscopy.

GND Ground.

Hg-ISMFET Mercury ion-selective membrane Field Effect transistors.

HPLC High-Performance Liquid Chromatography.

ICP-AES Inductively Coupled Plasma Atomic Emission Spectrometry.

ICP-MS Inductively Coupled Plasma Mass Spectrometry.

IDE Integrated Development Environment.

ITO Indium tin oxide.

LC-ICP-MS Liquid Chromatography Inductively Coupled Plasma Mass Spectrometry.

MCU Micro-Controller Unit.

MOSFET Metal–oxide–semiconductor field-effect transistor.

MR S-phone smartphone-based microwell reader.

MWCNTs multi-walled carbon nanotubes.

PANI polyaniline.

PO PH analog output.

PSM Projek Sarjana Muda.

RFP red fluorescent protein.

RGO Reduced graphene oxide.

TDS Total Dissolved Solids.

TO Temperature output.

URL Uniform Resource Locator.

UTEM Universiti Teknikal Malaysia Melaka.

VCC 5V DC.

CHAPTER 1

INTRODUCTION

1.1 Background of the project

The main reason for using mercury is as a "Lightner" skin. It can operate as a bleaching agent and has antibacterial characteristics, which means it can help the product last longer. In cosmetics, high quantities of mercury are employed, primarily in treatments that claim to remove dark spots, blemishes, and fine lines [1]. Mercury is typically found in cosmetics as inorganic salts such as mercuric chloride and mercuric oxide [2]. Although mercury is an effective skin-lightening agent with immediate results, the cost outweighs the benefit. Many pharmacological items, such as vaccinations, ointments, contact lens solutions, and ear, eye, and nose drop solutions, contain mercury as a preservative, antifungal, and antiseptic agent. It creates free radicals and has been classed as carcinogenic to human health. Skin rashes, such as dermatitis, eczema, acne, keratosis, discoloration, and scarring, can be caused by using mercury-containing skin lightening treatments on a regular basis, as well as impaired skin resistance to bacterial and fungal infections, and even skin cancer [1]. Mercury is a very volatile chemical with a long half-life in the atmosphere that can accumulate and cause major health concerns, and its widespread use in cosmetics may contribute to this. Long-term exposure to excessive mercury levels in cosmetics can result in major health problems, including kidney and gastrointestinal damage, as well as neurological impairment [1]. It can also convert microbial methylation into more deadly methylmercury, which can then build in the human body due to high enrichment factors, affecting the nervous, immunological, and digestive systems, as well as causing catastrophic kidney, liver, and brain damage. Anxiety, sadness, or psychosis, as well as peripheral neuropathy, are some of the other side effects. Despite the fact that some mercury-containing creams are prohibited to manufacture in the United States and other European countries, the usage of mercury-based whitening cosmetics has grown widely.

Most mercury determination techniques are based on analytical instrumentation methods [3]. These methods are highly sensitive, selective, and accurate, but they necessitate sophisticated sample preparation procedures, expensive and large instruments, and professionally trained individuals to perform the tests. Many of these tests are also not portable, necessitating the collection and return of samples to a laboratory for examination. As a result, they have a limited use and are not well suited for on-site mercury detection. The aim of this project is to investigate the relationship between the pH value and the harmful mercury substance in cosmetics. In this project, a circuit of NodeMCU ESP8266 connected with a pH sensor is used to detect harmful mercury substances in cosmetics. The pH sensor will help to accurately measure the pH value of cosmetics. The pH value range detected by the pH sensor is based on projects in the literature review of mercury detection in cosmetics. The pH value range set by the project is from pH 5 to pH 7. The data from the circuit will send an alarm or notification of the presence of mercury to the phone or computer.

1.2 Problem Statement

Mercury in cosmetics has been proven to cause serious health effects, but it is still often used in cosmetics as skin lightening products. Long-term exposure to mercury in cosmetics can cause kidney damage, anxiety and depression, memory loss, and other health effects. The detection of mercury in cosmetics is very important to solve this problem, and it can effectively distinguish whether cosmetics contain mercury.

1.3 Aim and Objectives

1.3.1 Aim

The aim of the project is to investigate the relationship between the pH value and the harmful mercury substance in cosmetics.

1.3.2 Objectives

The objectives of the project are:

1. To develop IoT Based mercury substance detector in cosmetic products.

2. To analyze the pH value of mercury substances in cosmetics.

1.4 Scope of Project

There are four main scopes of work that have been identified for this project. First of all, a suitable sensor to be used in this project is needed to find out to increase the accuracy of the output in the project. The pH sensor and Total Dissolved Solids (TDS) sensor along with other sensors are among the input sensor considered to be used. However, the pH sensor is used finally as it is more accurate compared to other sensors. Next, it is necessary to determine the pH value of mercury substances in cosmetics. The pH range of cosmetic mercury substances in the literature review is pH 5 to pH 7. After that, when the circuit and coding are finalized, the circuit will be constructed first on the breadboard before transferring to the UV board and the hardware of the circuit will be tested if there is a technical error. Then the circuit will be connected with the WIFI and tested if data can be sent to the computer or mobile phone.

1.5 Thesis Outline

This report will be conducted in a few chapters and each is stated as follow. Chapter 1 will briefly introduce the project. This chapter contains the background of the project, problem statement, objectives, the scope of the project, and thesis outline. Chapter 2 shows the studies and research relevant to the project. Chapter 3 will show the process of the project methodology used in this project. Chapter 4 will state the result and the discussion of the result that is obtained. Chapter 5 will discuss the summarization of the project and the future work of the project.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

The use of modern instruments based on spectroscopic and chromatographic techniques is typically used in traditional analytical procedures for detecting mercury in cosmetics, such as Atomic Absorption Spectroscopy (AAS), Graphite Furnace Atomic Absorption Spectroscopy (GFAAS), Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Liquid Chromatography Inductively Coupled Plasma Mass Spectrometry (LC-ICP-MS), High-Performance Liquid Chromatography (HPLC) with ICP-MS, Cold Vapor Atomic Absorption Spectrometry (CVAAS), and direct mercury analyzer [1,3]. The time-consuming procedures are a key disadvantage of the daily analysis and on-site inspection of many samples on-site, as these approaches have proven to be very accurate and sensitive, sophisticated, and expensive.

In addition to analytical instruments, there are other mercury detection technologies, such as colorimetry, electrochemistry, surface-enhanced Raman scattering, etc. Mercury is also detected via biosensors and chemical sensors. The complex, expensive, and time-consuming procedures connected with these approaches necessitate a simpler alternative method for daily analysis and on-site inspection of large numbers of samples, despite the fact that these methods have proven to be very accurate and sensitive. Despite these advancements, a sensor with simple operation, low cost, quick response, high sensitivity, good selectivity, and high reliability is still required for real-time on-site identification and quantification.

2.2 Previous works

2.2.1 Electrochemical Behaviour of Real-Time Sensor for Determination Mercury in Cosmetic Products Based on PANI/MWCNTs/AuNPs/ITO

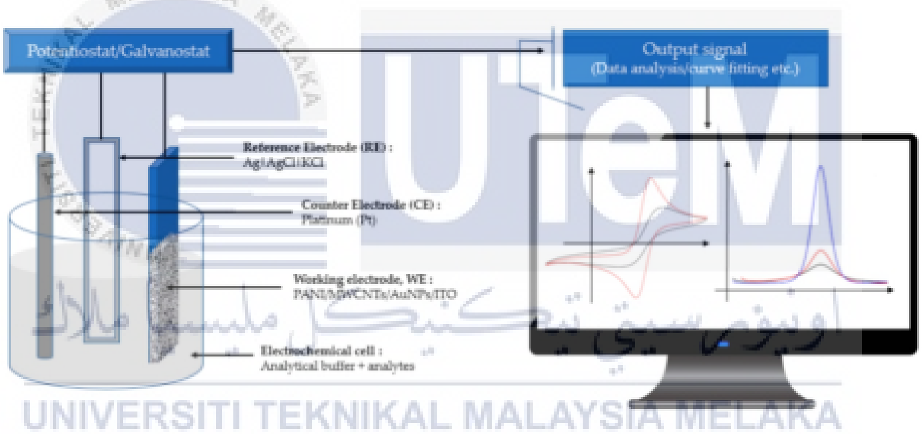

Figure 2.1: A Computer-controlled potentiostat with a three-electrode system.

Using methylene blue as a redox indicator, a rapid and sensitive electrochemical approach was devised to evaluate mercury in cosmetic products with the composition of polyaniline/multi-walled carbon nanotubes/gold nanoparticles/indium tin oxide sheet [1]. For the construction of an electrochemical sensor for the detection of mercury ions, Indium tin oxide (ITO) was employed as a transparent working electrode [4]. The electrode was modified by placing polyaniline (PANI), multi-walled carbon nanotubes (MWCNTs), and gold nanoparticles (AuNPs) directly on it, and then analytes and operating conditions were tweaked to improve the electrode's selectivity, sensitivity, and reliability for mercury detection [1,4]. The findings of this study reveal that the modified electrode behaves electrochemically under optimal conditions.

This shows that mercury detection has a high level of repeatability and sensitivity. However, this method is difficult to implement because it modifies the sensor, which complicates the development process of the project.

2.2.2 Instant Mercury Ion Detection with a Microchip Using Extended Gate Field-Effect Transistors and a Portable Device

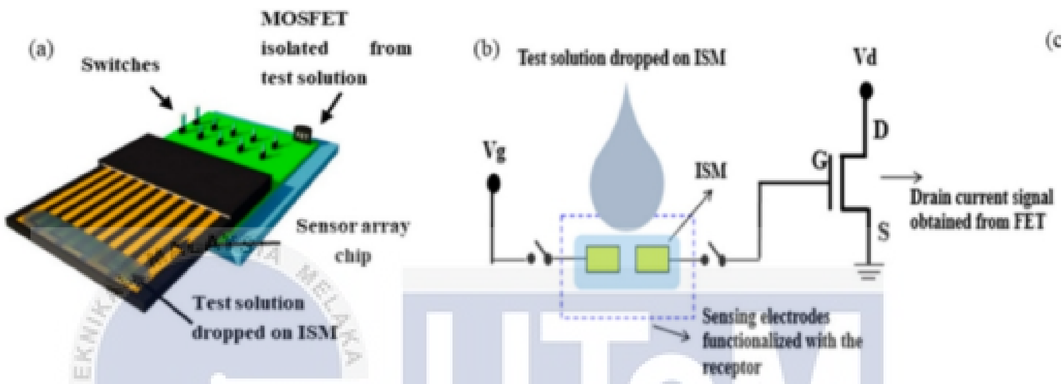

Figure 2.2: Schematic representation of extended gate HG-ISMFET connected to the prototype and Structural representation of extended gate Hg-ISMFET.

In this study, researchers devised a gadget with a simple user interface and a quick response time (less than five minutes) that can infer the quantity of mercury ions in a blind test solution. An N-channel depletion DMOS FET was employed in this experiment [5]. The linear section is where the MOSFET is meant to work. It has good thermal characteristics and is suitable for amplification applications. Single mode and burst mode are the two operating modes based on the user interface software. In single-mode operation, collect a single measurement, and in burst mode operation, gather many repeated measurement data. Throughout the work, a burst operation mode was adopted [5, 6]. Each sensing electrode is tested using the switch. A short-time pulsed gate voltage with an amplitude of 1 V and a width of 100 s is employed as the gate bias at the reference electrode. Throughout the process, a 2 V drain-source voltage is used [5]. However, the effectiveness of this method is difficult to determine because it has not been implemented and tested for mercury substance in cosmetics.

2.2.3 A Portable Smart-Phone Readout Device for the Detection of Mercury Contamination Based on an Aptamer-Assay Nanosensor

Figure 2.3: Schematic illustration of the microwell reader installed on an Android-based smartphone and image of the actual optical microwell reader.

In this study, a battery-powered accessory was designed that can be attached to a smartphone's ambient light sensor and used to assess mercury levels in aqueous samples using a colorimetric aptamer nanosensor [7, 8]. Signals from a smartphone-based microwell reader (MR S-PHONE), which consists of a basic light source and a tiny analysis platform, are detected, recorded, and processed using a smartphone with a photometer application. The aptamer nanosensor's colorimetric reading is based on a specific interaction between the selected aptamer and mercury, which can cause the colour of the reaction solution to change due to gold nanoparticle aggregation (AuNPs) [7, 8]. The AuNPs-aptamer colorimetric sensor system, which is based on an MR S-phone, can accurately detect mercury [7]. It only takes 20 minutes to quickly complete the test. However, the effectiveness of this method is difficult to determine because it has not been implemented and tested for mercury substance in cosmetics.

2.2.4 Real-time detection of mercury ions using a reduced graphene oxide/DNA field-effect transistor with the assistance of a passivation layer

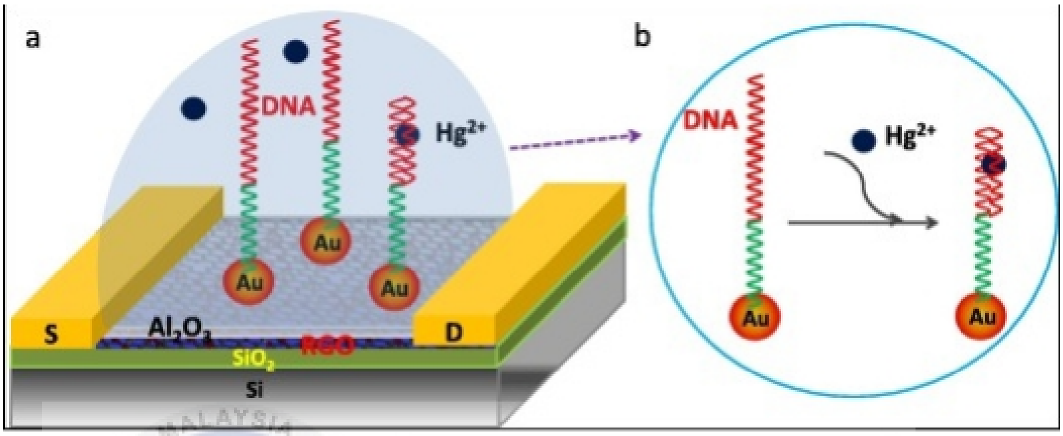

Figure 2.4: Schematic illustration of the Al2O3/rGO transistor functionalized with AuNPs and DNA probes.

An RGO FET water sensor platform with Passivation layer (AL2O3) was designed in this study, and it demonstrated a highly sensitive and selective response to different mercury ion concentrations [9]. The sensor displayed a clear gate effect mechanism with a passivation layer to safeguard the devices' electrical stability, which could help us increase sensing performance. Through Au-thiol interactions, probe DNA was consistently attached onto Au NP surfaces, and this method outperforms previous chemical methods due to the homogeneous distribution of Au NPs on the devices [9, 10]. A fast response (few seconds) and a much lower detection limit confirmed the sensor's sensing capability (1 nM) [9]. Furthermore, the sensor demonstrated excellent selectivity in mixed liquids. However, the effectiveness of this method is difficult to determine because it has not been implemented and tested for mercury substance in cosmetics.

2.2.5 Highly Sensitive Electrochemical Detection of Mercury Present Using Graphene Modified Glassy Carbon Electrode

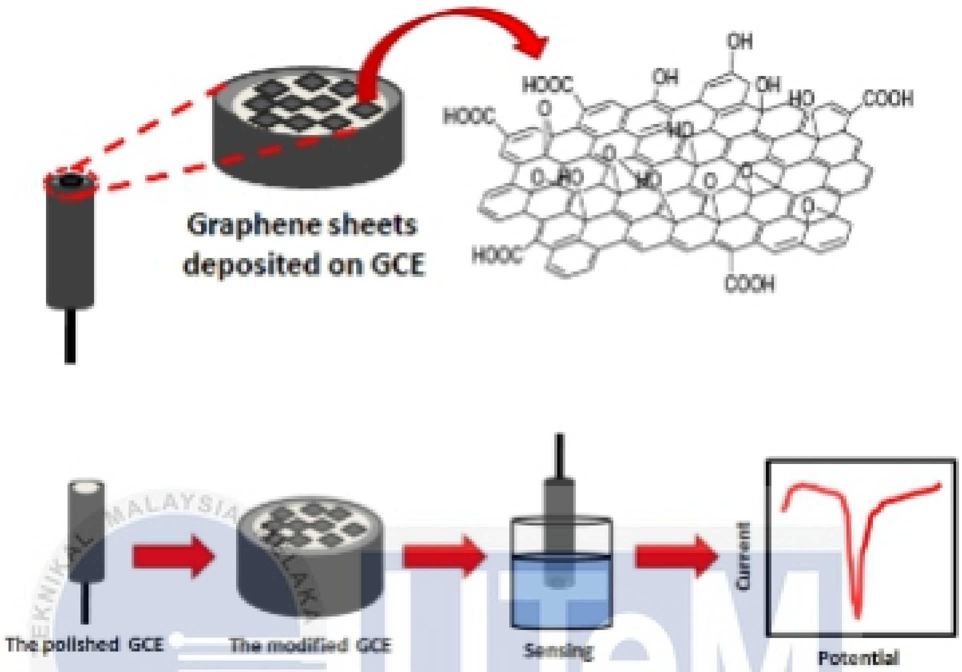

Figure 2.5: Highly Sensitive Electrochemical Detection of Mercury Present Using Graphene Modified Glassy Carbon Electrode

It has been confirmed that graphene-modified glassy carbon electrodes may be used in electrochemical detection of mercury ions in cosmetic cream samples [11]. The electrochemical approach is used to determine the mercury concentration. Before analysis, the cream is acid digested, and the sample is described using a scanning electron microscope and Raman spectroscopy [11]. A graphene-modified glassy carbon electrode was used to measure mercury concentrations. The electrochemical response to mercury is considerably enhanced by the presence of graphene sheets on the glassy carbon electrode [11, 12]. The results show that the electrode is accurate and sensitive, and can be used to detect mercury ions in actual samples. However, this method is difficult to implement because it modifies the sensor, which complicates the development process of the project.

2.2.6 A test strip platform for detection of total inorganic mercury pollutants in cosmetics based on a whole-cell microbial biosensor

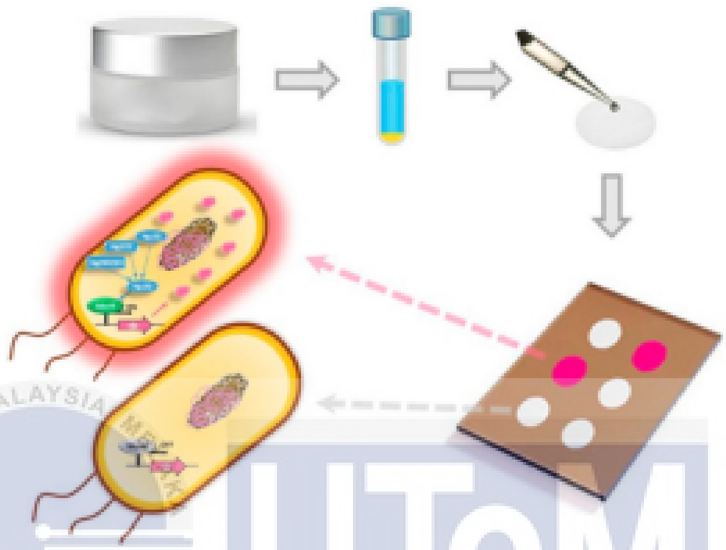

Figure 2.6: A test strip platform based on a whole-cell microbial biosensor

A test strip platform based on a whole-cell microbial biosensor was created in this study for the simultaneous detection of soluble and insoluble inorganic mercury contaminants in cosmetics without the need for pre-digestion [13]. To create a mercury detection biosensor, a genetic circuit with constitutively expressed MerR as a sensor protein and inducible red fluorescent protein (RFP) as a reporter was introduced into Escherichia coli. The RFP fluorescence intensity of this biosensor has an excellent linear relationship with mercury concentrations in Luria-Bertani broth ranging from 50 nM to 10 uM [13]. From the standpoint of gene expression, the transcriptomics data supported the whole-cell biosensor's ability to convert mercury. The biosensor is placed in the filter paper to create a test strip that can be used to see if the total amount of inorganic mercury in cosmetics is greater than 1 mg/kg [13]. As a result, this strip offers a low-cost, simple-to-use, and instrument-independent way to detect mercury contamination in cosmetics. However, this method is difficult to implement because it uses biosensors, which complicates the development process of the project.

2.3 Summary

There are many kinds of research related to this project from other persons outside and inside the country. As the world is developing, the use of technologies is widely be used to create and invent a product. The ideas from the previous inventors are being modified and they will make a great comeback with improvement. The mercury substance detector has commercial products on the global market. For the product on the market, it is very versatile. It can be used to detect mercury substances in cosmetic products and notify people of the presence of mercury and take actions to avoid serious health effects, including kidney damage, anxiety and depression, and memory loss.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the method and process of designing the circuit and system from the hardware and software parts. This project consists of four main parts. First, it is vital to find a suitable sensor to be implemented in this project. This is because this project requires high accuracy to detect the mercury substance in cosmetics. Other than that, the offset potentiometer needs to be turned to get the correct offset to ensure that the pinout PO of the module is 2.5V. Next, is to construct the circuit and develop Arduino code. The circuit and the code will be troubleshot according to the project requirement if there is any problem occur. Then the hardware of the circuit will be integrated with IoT with the help of Blynk Software and Google Spreadsheet, as the data from NodeMCU will be directly sent online into Blynk and Google Spreadsheet.

3.1.1 Methodology Flow Chart

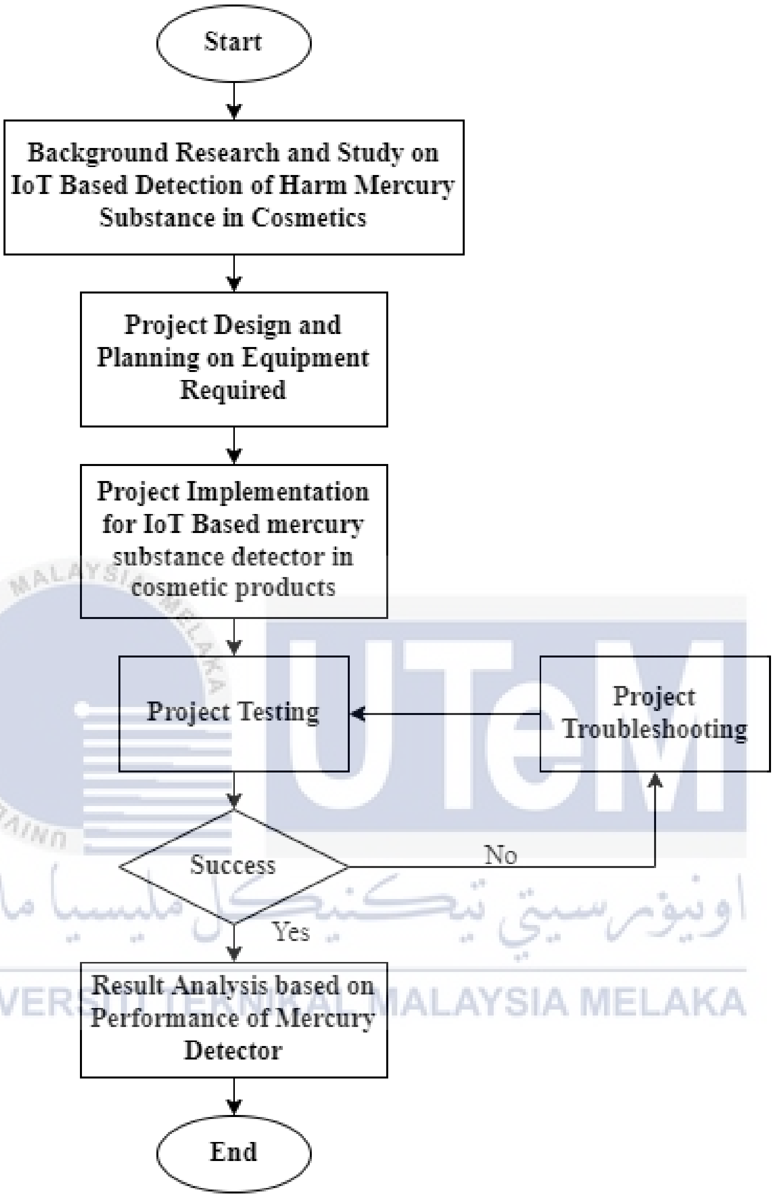

Figure 3.1: Flow Chart of the Methodology

The procedure that will be carried out in this project is to conduct background research and study on the title of the project. Next, research will be conducted to determine the components that will be used in the project. After that, the circuit design of the project will be determined, and each component will be tested before the circuit is built to ensure that these components are working properly. After ensuring that the components are working properly, the circuit will be built as planned, and the circuit will be tested after uploading the system code to the NodeMCU microcontroller.

3.1.2 Project Flow Chart

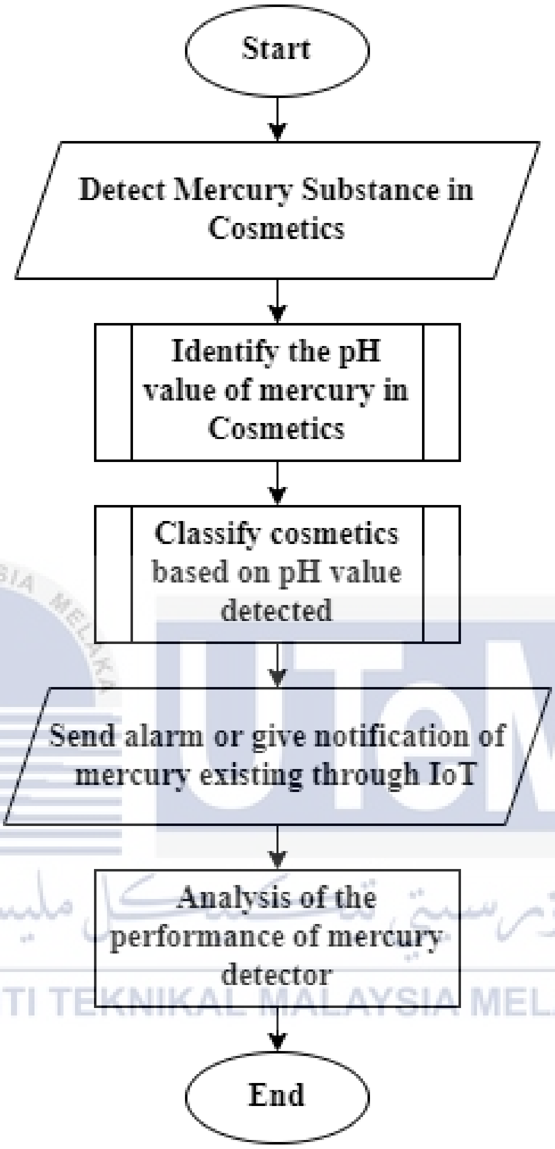

Figure 3.2: Flow Chart of the Project

The flow of the project is that when the pH sensor detected harmful mercury substances in cosmetics, the Blynk software will display the pH value of mercury. Since this project will be an IoT-based mercury substance detector, the pH value obtained will be displayed on a mobile phone or computer. The expected result of the project is that when mercury in cosmetics is detected, the data from the detector will send an alert or give notification of mercury existing.

3.2 Cosmetic Sample Preparation

The five samples of creams were obtained from the local market in Melaka, Malaysia. These creams were selected as they were inexpensive, famous, and bought abundantly. The date of production was demonstrated clearly and creams had no ointment in them.

Table 3.1: Different brands of skin-lightening creams available in Malaysia

No.	Brand	Ingredients Mentioned on Packaging
1	Temulawak	petrolatum, mineral oil, isopropyl myristate, titanium dioxide carnauba wax, beeswax propylparaben perfume, methylparaben, and iron oxide yellow
2	Collagen	stearic acid, lanolin, parfum, aqua, propylparaben, and triethanolamine.
3	Breylee	Vitamin C, Aqua, Butyrospermum Parkii (Shea Butter), Hydrolyzed Yeast Protein, Glycerin, 3-O-Ethyl Ascorbic Acid, Sodium Hyaluronate
4	Men's anti-aging	sodium hyaluronate nicotinamide.
5	Anfany	Aqua, Butyrospermum Parkii (Shea Butter), Hydrolyzed Yeast Protein, Glycerin, 3-O-Ethyl Ascorbic Acid, and Sodium Hyaluronate.

3.3 Hardware Implementation

Hardware implementation means that the job was done using a physical device or electronic circuit as opposed to being done by a computer program.

3.3.1 Project Overview

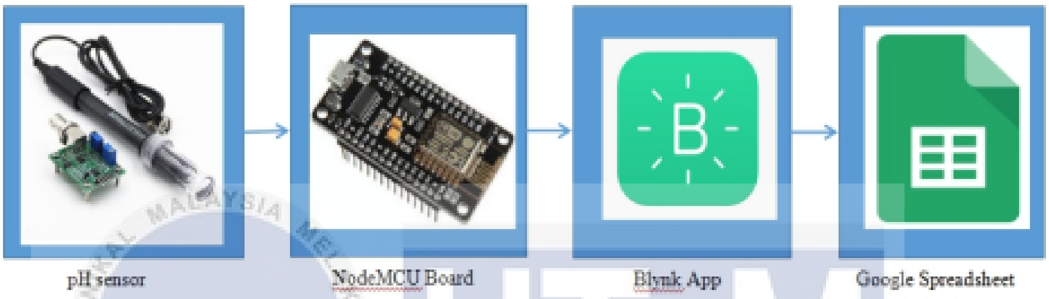

Figure 3.3: Overview of the Project

The pH sensor will first detect the pH value of mercury substances in cosmetics. When it detects the pH value in the cosmetics, it will send information to NodeMCU, and then update the data in the Blynk and Google spreadsheets. When Blynk's data is updated, the user's mobile phone will notify the presence of mercury. The user also can view the Google spreadsheets online to check the pH value of the cosmetics detected in the past from anywhere as long as it has a data connection. The pH setting for detecting mercury-containing substances is based on the research outlined by U. Ekpunobi (2014) and M. Arshad (2021) [14, 15]. These two studies show that the pH value of most mercury-containing cosmetics is acidic, so this project is set the pH range is pH 5 to pH 7.

3.3.2 Schematic Diagram of the Project

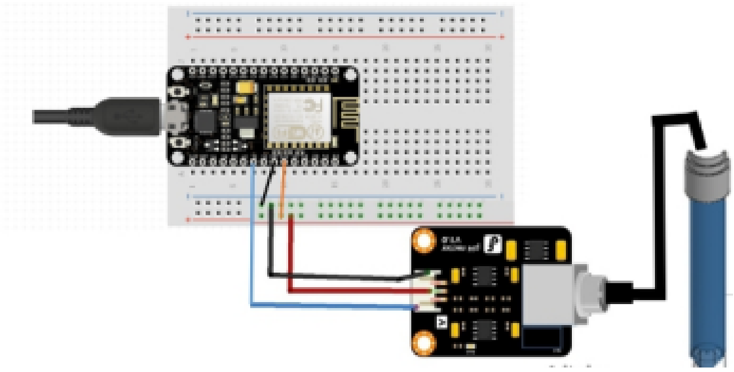

Figure 3.4: Schematic Diagram of the Project

The connection of the project is as follows. In the pH-4502C sensor module, there are 6 pins on it which are ‘TO’, ‘DO’, ‘PO’, ‘GND’, ‘GND’, and ‘VCC’. The 3.3V pin from NodeMCU is connected to the VCC pin of the pH sensor. The PO pin of the pH-4502C sensor module is connected to pin A0 of the NodeMCU. The ground pin of the sensor module is connected to the ground pin of the NodeMCU.

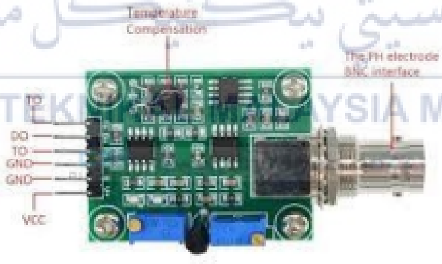

Figure 3.5: The pinout of the pH-4502C sensor module

In the Logo-Rnaenaor v2.0 sensor module, there are also 6 pins on it which are ‘T2’, ‘T1’, ‘PO’, ‘GND’, ‘GND’, and ‘VCC’. The 3.3V pin from NodeMCU is connected to the VCC pin of the sensor module. The PO pin of the Logo-Rnaenaor v2.0 sensor module is connected to pin A0 of the NodeMCU. The ground pin of the sensor module is connected to the ground pin of the NodeMCU.

These two sensor modules, like any other sensor that connects to an analog pin, can produce a voltage output to the analog board that represents a PH value. A PH of 0 should represent 0V, and a PH of 14 should indicate 5V. However, these modules have pH 7 set to 0V by default, which means that when reading acidic pH values, the voltage will go into the negatives, which cannot be read by the analog Arduino port. The offset potentiometer in these modules is used to modify this so that a pH 7 will read the expected 2.5V to the Arduino analog pin. The analog pin can read voltages between 0V and 5V, thus the 2.5V is halfway between 0V and 5V, much like a PH 7 is halfway between PH 0 and PH 14.

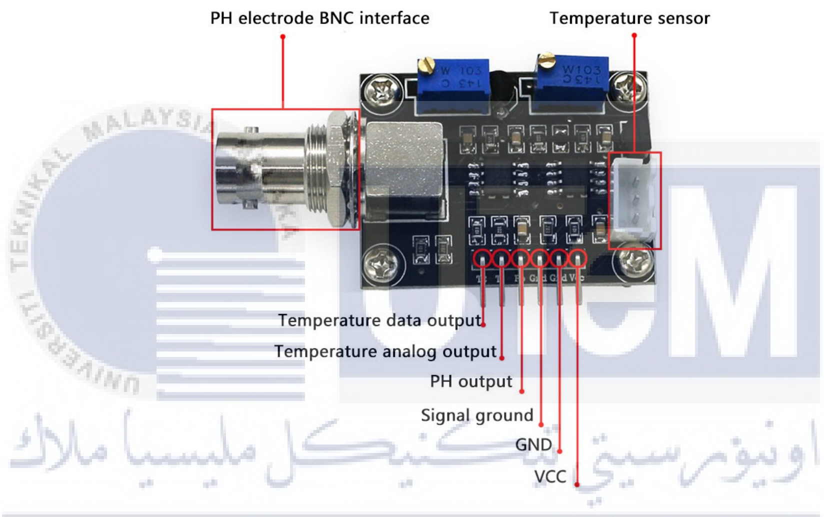

Figure 3.6: The pinout of the Logo-Rnaenaor v2.0 sensor module

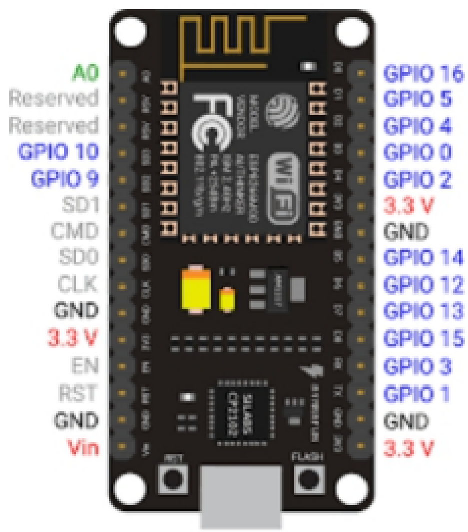

Figure 3.7: The pinout of the NodeMCU Board

3.3.2.1 Comparison of pH sensor modules

Table 3.2: Comparison of pH sensor modules

	Sensor Module	pH-4502C	Logo-Rnaenaor v2.0
1	Sensor Pinout	TO–Temperature output pin DO–3.3V pH limit trigger PO–PH output pin (Analog Pin) GND–Analog Sensor GND GND–Power supply Ground VCC–Positive Power supply pin	T2–Output pin of DS18B20 waterproof temperature sensor (Digital Pin) T1–Output pin of onboard temperature sensor LM35 (Analog Pin) PO–PH output pin (Analog Pin) GND–Analog Sensor GND GND–Power supply Ground VCC–Positive Power supply pin
2	Potentiometer	POT 1–Analog reading offset POT 2–PH limit setting	POT 1–Analog reading offset POT 2–PH limit setting
3	Heating voltage	5±0.2V (AC/DC)	5±0.2V (AC/DC)
4	Operating current	5-10mA	5-10mA
5	PH detection range	PH0-14	PH0-14
6	Temperature detection range	0-80°C	0-100°C
7	Response time	5s	5s
8	Stable time	60s	60s

By comparing pH-4502C and Logo-Rnaenaor v2.0 sensor module, the temperature detection range of the Logo-Rnaenaor v2.0 sensor module is wider than that of the pH-4502C sensor module. By comparing the six pinouts of pH-4502C and Logo-Rnaenaor v2.0 sensor modules, they have two different pinouts. The different pinouts of pH-4502C are pin TO (Temperature output pin) and pin DO (3.3V pH limit trigger pin); while the pinouts of the Logo-Rnaenaor v2.0 sensor module are pin T1 (Temperature output pin of onboard temperature sensor LM35) and pin T2 (Temperature output pin of DS18B20 waterproof temperature sensor). The other four pinouts of these two sensor modules include pin PO (PH output pin), pin GND (Analog Sensor Ground pin), pin GND (Power supply Ground pin) and pin VCC (Positive Power supply pin) are same. The potentiometer, heating voltage, operating current, pH detection range, response time, and stable time of these two sensor modules are also the same. If only the PH detection range is considered, the two sensor modules are the same, but the Logo-Rnaenaor v2.0 sensor module is better than the pH-4502C sensor module when considering the temperature detection range.

3.3.3 Steps to set the offset of the pH sensor module

Figure 3.8: The connection of the BNC interface

The offset potentiometer needs to turn to get the right offset, the offset potentiometer is the blue potentiometer nearest to the BNC connector. Setting the offset is fairly easy. First, the BNC interface of the module needs to be disconnected from the pH electrode probe. Next, the inside of the BNC connector of the module needs to short-circuit with the outside of the BNC interface of the module by using a wire. After that, this module needs to connect to the NodeMCU by using connecting wire. Then, the offset potentiometer needs to adjust until the pinout PO of the module measures 2.5V.

3.3.3.1 Arduino Code for Analog Voltage Read

If there is no multimeter, this Arduino code can use to measure the pinout PO of the sensor module. The explanation of the coding is written next to code after '//' and is colour green for better understanding.

```
// the setup routine runs once when you press reset:
void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
}
// the loop routine runs over and over again forever:
void loop() {
  int sensorValue = analogRead(A0); // read the input on analog pin 0.
  // Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V):
  float voltage = sensorValue * (5 / 1023.0);
  Serial.println(voltage); // print out the value you read.
  delay(300);
}
```

Figure 3.9: Arduino Code for Analog Voltage Read

3.4 Software Implementation

The software implementation is a systematically structured approach to effectively integrate a software-based component into a project.

3.4.1 Blynk Software Settings

The data from the detector will be sent by NodeMCU to the Blynk software on the mobile phone in real-time. The following shows the way to set up the Blynk software.

1. Download the Blynk software on the phone and create a Blynk account.
2. Log in to Blynk account and create a new project.

3. Select the hardware model that will be used in the project. This project uses NodeMCU with Wifi.

-

Figure 3.10: The Blynk hardware model of the Project

4. Click the "Create" button and the Auth Token will be sent to the email.

5. Add widgets used in the project. The widgets used in this project are Notification, LCD, and Gauge.

6. Press 'Play' button to run the project

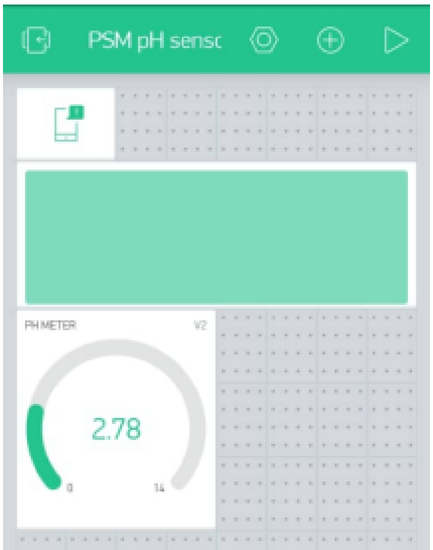

Figure 3.11: The widgets used in the Project

3.4.2 Google Spreadsheet Creation

The data from the NodeMCU will be view and store in Google Spreadsheet. Below shows the way to create a Google Spreadsheet.

1. Gmail account was log in and then Google Drive was open.
2. A new folder was created, named and the folder was opened.
3. The folder was opened and right-click to open Google Sheets.
4. Google Sheet is then created inside the folder, then the Spreadsheet will be open in a new tab. The Spreadsheet as then named.
5. According to the needs of the program, the field in Spreadsheet table was named.
6. Tools were clicked to open Script editor where a new Script editor will be opened.

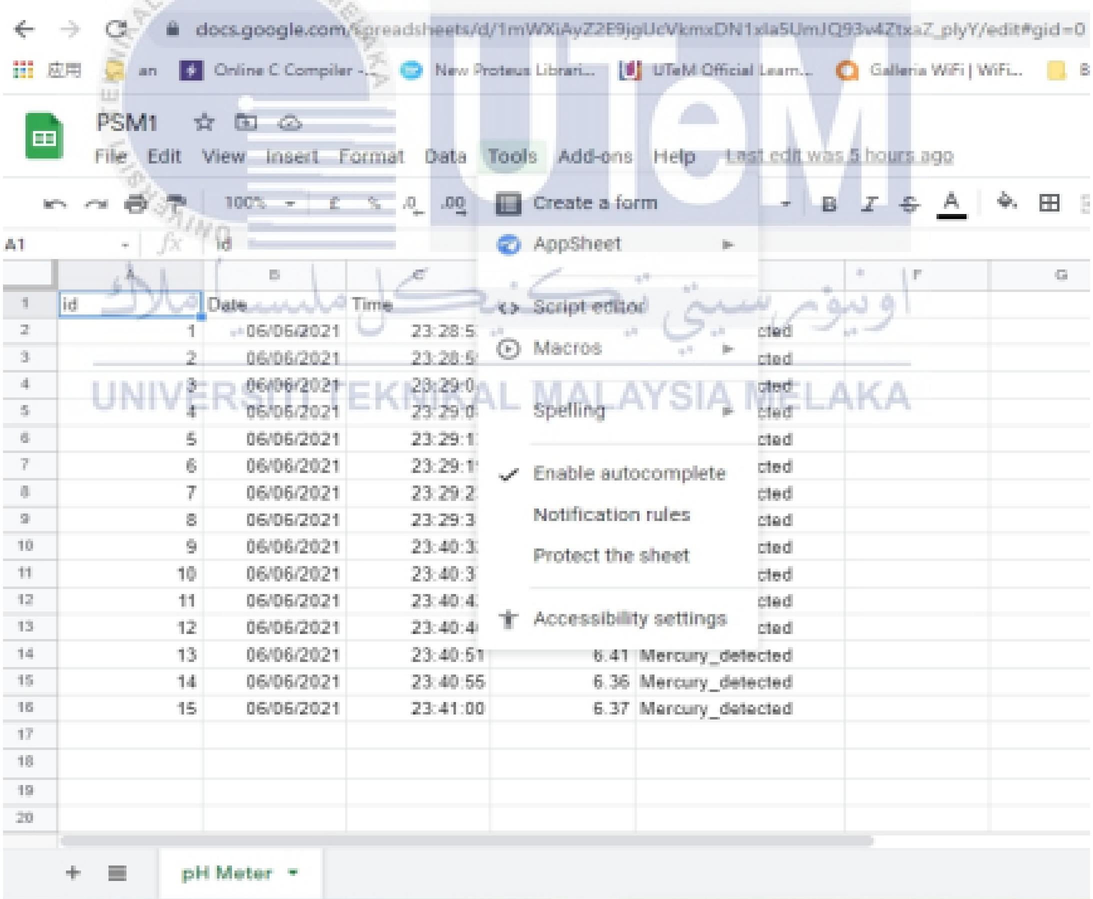

Figure 3.12: Script editor tool button of the Google Spreadsheet

-

7. The Script editor was named and the coding of Script editor was written in it.

8. The coding was saved.

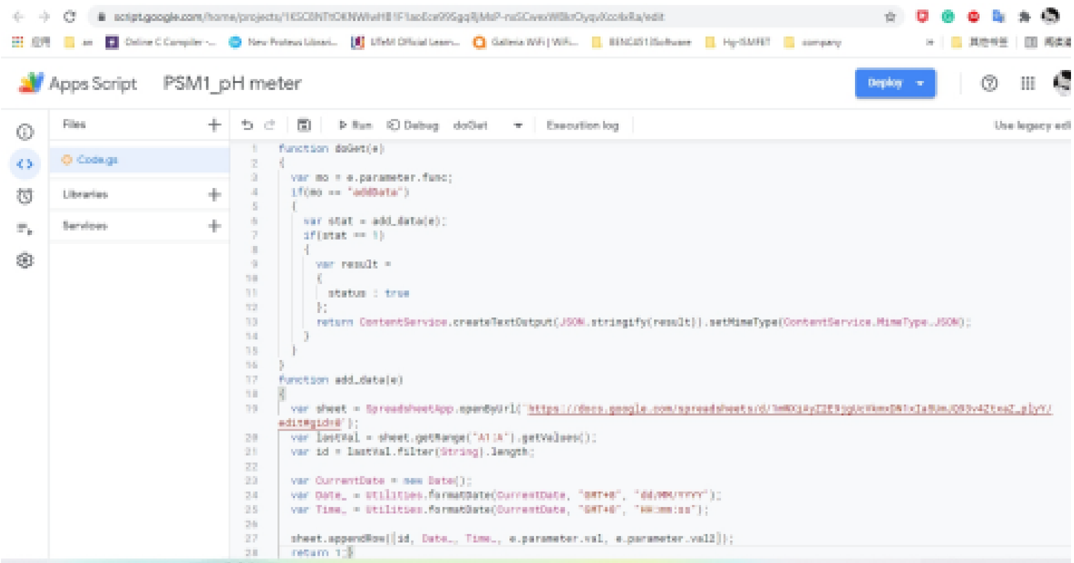

Figure 3.13: Script editor of the Google Spreadsheet

9. Publish was clicked to select Deploy as web app.

10. Under Deploy as web app, Project version was entered as my function and anyone was selected, even anonymous for the access to the app, Deploy icon was clicked.

11. Permission was asked, to give permission, "Give permission icon" as clicked.

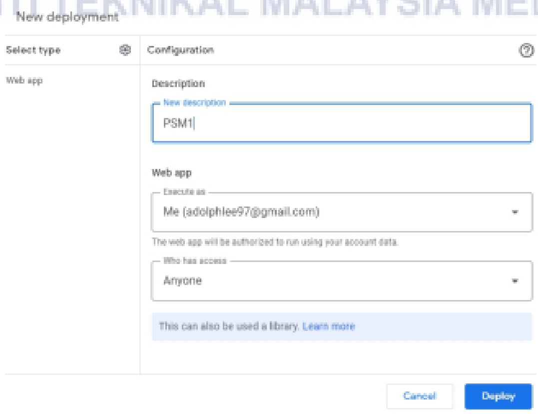

Figure 3.14: Deploy as a web app

12. Google account was then select, then 'allow to give permission' was click.

13. A web app URL was given, the URL was noted and click ok.

3.4.2.1 Google Spreadsheet Creation

The code of the script editor is a Google spreadsheet used to receive data from NodeMCU and store it in the spreadsheet. The explanation of the coding is written next to code after '//' and is colour green for better understanding.

```
function doGet(e) {
  var mo = e.parameter.func;   //active e.parameter.func.
  if(mo == "addData") {   //'If' function, if add data to Google Spreadsheet.
    var stat = add_data(e);  //do the 'function add_data(e)'.
    if(stat == 1) {   //'If' function, if add data successfully.
      var result =
      {
       status : true   //The 'status: true' will be generated.
      };
        return ContentService.createTextOutput(JSON.stringify(result)).setMi
meType(ContentService.MimeType.JSON);
//Serve the Content as JSON using Google Apps Script Content Service and send
 data.
      }
  }
```


Figure 3.15: The Coding of the Script editor

```
function add_data(e) {

  var sheet = SpreadsheetApp.openByUrl('https://docs.google.com/spreadsheets/d/1mWXiAyZ2E9jgUcVkmxDN1xIa5UmJQ93v4ZtxaZ_plyY/edit#gid=0');
//get Active Google Spreadsheet

  var lastVal = sheet.getRange("A1:A").getValues();     //the numbers in order starting from 1 in coloumn A

  var id = lastVal.filter(String).length;   //add lastVal to column id

  var CurrentDate = new Date();

  var Date_ = Utilities.formatDate(CurrentDate, "GMT+8", "dd/MM/YYYY");
 // get the current date

  var Time_ = Utilities.formatDate(CurrentDate, "GMT+8", "HH:mm:ss");
 // get the current time

  sheet.appendRow([id, Date_, Time_, e.parameter.val, e.parameter.val2]);
 // add new row

  return 1;

}
```

Figure 3.16: The Coding of the Script editor, continued

3.4.3 Arduino IDE Software Settings

Arduino IDE is the software for developing NodeMCU coding. In this software code, the pH sensor data will be sent by NodeMCU to the Blynk software on the phone in real-time and will be viewed and stored in a Google spreadsheet. The following shows the way to install Blynk Library and ESP8266 Add-on in Arduino IDE.

3.4.3.1 Install ESP8266 Add-on in Arduino IDE

To install the ESP8266 board in Arduino IDE, follow these next instructions:

1. In the Arduino IDE software, go to File> Preferences.
2. Enter http://arduino.esp8266.com/stable/package-esp8266com-index.json into the

"Additional Boards Manager URLs" field as shown in the figure below. Then, click the "OK" button.

-

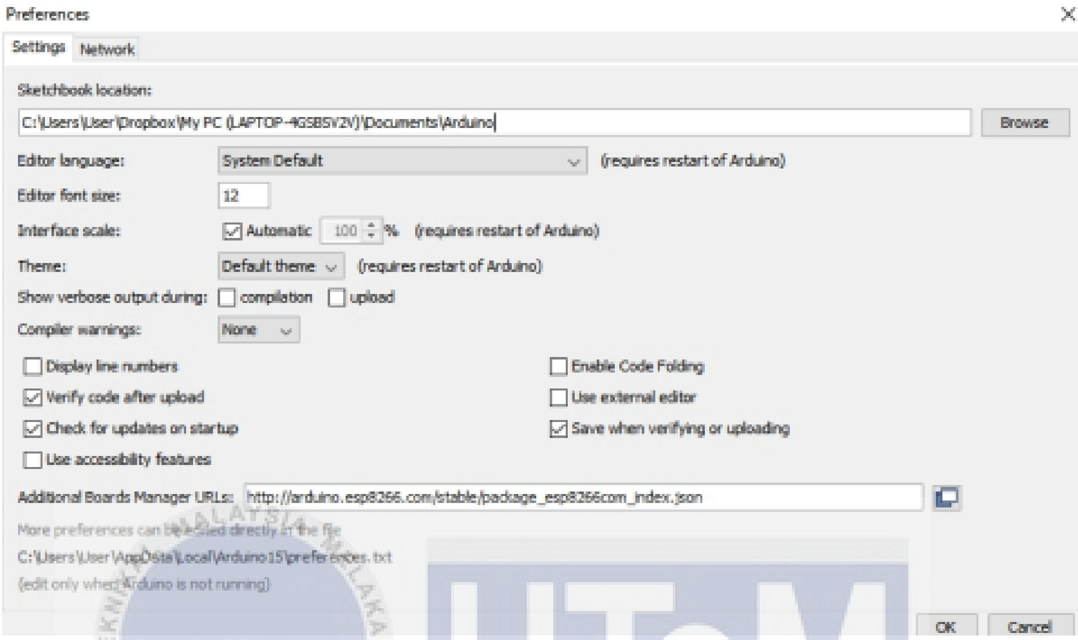

Figure 3.17: Preferences settings of Arduino IDE software

3. Open the Boards Manager. Go to Tools > Board > Boards Manager.

4. Search for ESP8266 and press the install button for the "ESP8266 by ESP8266 Community".

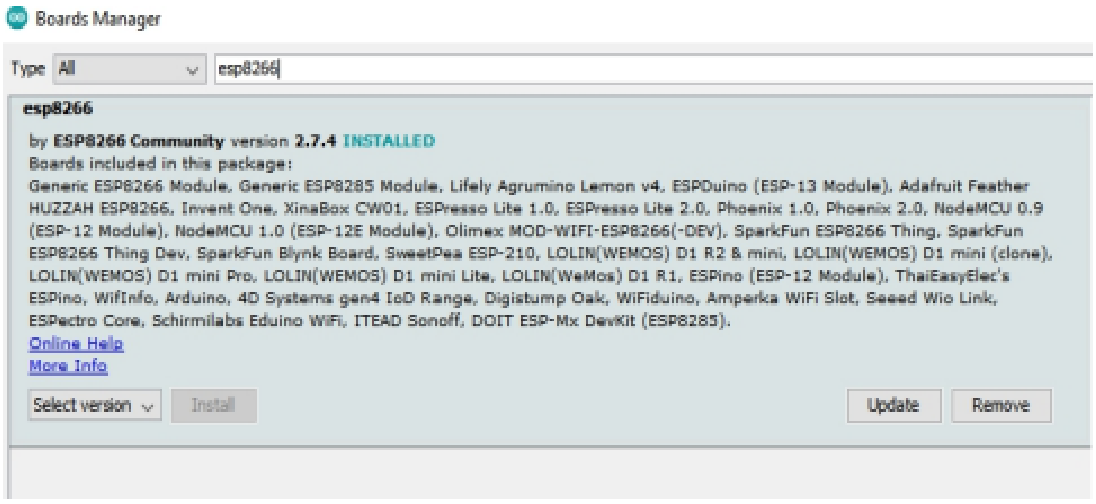

Figure 3.18: Boards Manager for ESP8266 Add-on

3.4.3.2 Install Blynk Library in Arduino IDE

To install the Blynk library into Arduino IDE, follow these next instructions:

1. Open the Arduino IDE and click on the "Sketch" menu and then Include Library > Manage Libraries.
2. Search the Blynk library and select the latest version in the version selection.
3. Finally, click on Install and wait for the Arduino IDE to install the Blynk library.

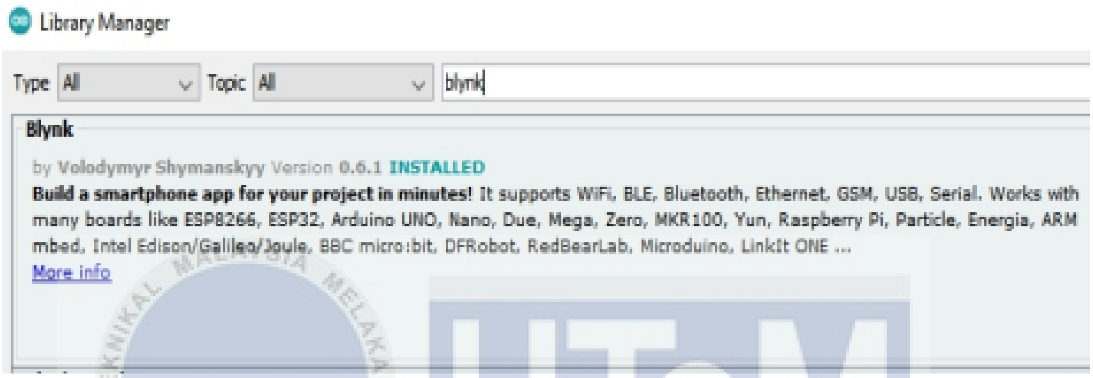

Figure 3.19: Library Manager for Blynk Library installation.

3.4.3.3 The Coding of Arduino IDE

In this Arduino code, the pH sensor data will be sent by NodeMCU to the Blynk software on the phone in real-time and will be viewed and stored in a Google spreadsheet. The explanation of the coding is written next to code after '//' and is colour green for better understanding.

```
#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>

#include <WiFiClientSecure.h>

#include <BlynkSimpleEsp8266.h>


WidgetLCD lcd(V2); // Blynk LCD Widget setting

char auth[] = "DYx8r1f5zaQDGnl2UxWpqd0kWdggJEgE"; // Blynk Auth Token

char ssid[] = "HUAWEI nova 4e"; // the name of the SSID

char pass[] = "libra6123"; // the password of the SSID

const char*host = "script.google.com"; // Google Spreadsheet website

const char* fingerprint = "2c 12 22 5e af 8a 22 84 c9 e1 84 41 ab ba 75 86 d1 dc bf 8f"; // The fingerprint of Google Spreadsheet

const int httpsPort = 443;

String url;

BlynkTimer timer;


#define SensorPin A0        //pH meter Analog output to Arduino Analog Input 0

unsigned long int avgValue;  //Store the average value of the sensor feedback

float b;

int buf[10],temp;
```


Figure 3.20: The Coding of this Project

-

-

```
void setup() {
pinMode(D0,OUTPUT);
Serial.begin(115200);
Serial.println("Ready");   //Test the serial monitor
delay(100);
Serial.println();
Serial.println();
Serial.print("Connecting to ");
Serial.println(ssid);
WiFi.mode(WIFI_STA);
WiFi.begin(ssid, pass);  //Connect to ssid
while (WiFi.status() != WL_CONNECTED) {
  delay(500);
  Serial.print(".");
}
Serial.println("");
Serial.println("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());
Serial.print("Netmask: ");
Serial.println(WiFi.subnetMask());
Serial.print("Gateway: ");
Serial.println(WiFi.gatewayIP());
Blynk.begin(auth, ssid, pass); //Connect to Blynk
timer.setInterval(1000L,sensorvalue1);
}
```

Figure 3.21: The Coding of this Project, continued

-

```
void loop() {
 Blynk.run();  //Run the Blynk
 timer.run();
}
void sensorvalue1() {
 WiFiClientSecure client;
 client.setInsecure();
 Serial.print("connecting to ");
 Serial.println(host);

 if (!client.connect(host, httpsPort)) {  //Connect to Google spreadsheet.
  Serial.println("connection failed");
  return;
 }

 if (client.verify(fingerprint, host)) {    //Verify the fingerprint of Google spreadsheet.
  Serial.println("certificate matches");
 }
 else {
  Serial.println("certificate doesn't match");
 }
```


Figure 3.22: The Coding of this Project, continued

```
  for(int i=0;i<10;i++)  {      //Get 10 sample value from the sensor for smooth
the value
    buf[i]=analogRead(SensorPin);
    delay(10);
  }
  for(int i=0;i<9;i++)  {   //sort the analog from small to large
    for(int j=i+1;j<10;j++) {
      if(buf[i]>buf[j]) {
        temp=buf[i];
        buf[i]=buf[j];
        buf[j]=temp;
      }
    }
  }
avgValue=0;
for(int i=2;i<8;i++)                //take the average value of 6 center sample
  avgValue+=buf[i];
float phValue=(float)avgValue*5.0/1024/6; //convert the analog into millivolt

//convert the millivolt into pH value
phValue = ((7 + ((2.5 - phValue) / 0.17)));
```


Figure 3.23: The Coding of this Project, continued

-

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```
Serial.print("    pH:");
  Serial.print(phValue,2);
  Serial.println(" ");
  digitalWrite(D0, HIGH);
  delay(1000);
  digitalWrite(D0, LOW);

  lcd.print(0,0,"pH Value:");
  lcd.print(0,1,phValue);
  Blynk.virtualWrite(V2, phValue);      //Display the pH value on Blybk's LCD

// project pH range setting from pH 5 to pH 7
  if (phValue > 7){
    Serial.println("Mercury not detected!");
    url="/macros/s/AKfycby8rC2YGAi5CrGqX-
09RVPD8sSa4b8tOmlOxxIj2NhBY4_TyBeEp6EEiG4WYmMDgmdd/exec?func
=addData&val2=Mercury_not_detected&val="+String(phValue); // the URL that
send data to Google spreadsheet
  }
  else if (phValue > 5) {
    Blynk.notify("Mercury detected!"); //Notification of Blynk
    Serial.println("Mercury detected!");
    url="/macros/s/AKfycby8rC2YGAi5CrGqX-
09RVPD8sSa4b8tOmlOxxIj2NhBY4_TyBeEp6EEiG4WYmMDgmdd/exec?func
=addData&val2=Mercury_detected&val="+String(phValue);
  }
  else {
    Serial.println("Mercury not detected!");
    url="/macros/s/AKfycby8rC2YGAi5CrGqX-
09RVPD8sSa4b8tOmlOxxIj2NhBY4_TyBeEp6EEiG4WYmMDgmdd/exec?func
=addData&val2=Mercury_not_detected&val="+String(phValue);
  }
```

Figure 3.24: The Coding of this Project, continued

-

-

-

```
Serial.print("Requesting URL: ");
Serial.println(url);
client.print(String("GET ") + url + " HTTP/1.1\r\n" +
            "Host: " + host + "\r\n" +
            "User-Agent: BuildFailureDetectorESP8266\r\n" +
            "Connection: close\r\n\r\n");
while (client.connected()) {
  String line = client.readStringUntil('\n');
  if (line == "\r") {
    Serial.println("headers received");
    break;
  }
}
String line = client.readStringUntil('\n');
if (line.startsWith("{\"state\":\"success\"")) {
  Serial.println("esp8266/Arduino CI successfull!");
}
```


Figure 3.25: The Coding of this Project, continued

-

3.5 Project Planning

H. PERANCANGAN PROJEK
PROJECT PLANNING (GANTT CHART)

Senaraikan aktiviti-aktiviti yang berkaitan bagi projek yang dicadangkan dan nyatakan jangka masa yang diperlukan bagi setiap aktiviti.
List all the relevant activities of the proposed project and mark the period of time that is needed for each of the activities.

	SEM I																		
Aktiviti Projek *Project Activities*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Select title and identify available components	X	X	X																
Proposal writing and Prepare for the proposal defence			X	X															
Construct the circuit and draft the Arduino code				X	X	X													
Testing and troubleshooting the circuit and the program (if needed)					X	X	X	X	X	X									
Prepare for the PSM 1 presentation												X	X	X					
Technical Report Writing						X	X	X	X	X	SEMINAR PSM I	X	X	X					
Logbook Writing	X	X	X	X	X	X	X	X	X	X		X	X	X					
Thesis and Technical Paper Writing																			
Prepare for PSM 2 INOTEK																			
Prepare for the PSM 2 presentation																			
Submission of final draft to supervisor and panels														X	X				
Literature Review	X	X	X	X	X	X	X	X	X	X		X	X	X	X				

	SEM BREAK					SEM II															
Aktiviti Projek *Project Activities*	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Select title and identify available components																					
Proposal writing and Prepare for the proposal defence																					
Construct the circuit and draft the Arduino code																					
Testing and troubleshooting the circuit and the program (if needed)																					
Prepare for the PSM 1 presentation																					
Technical Report Writing																					
Logbook Writing						X	X	X	X	X	X	X	X	X	X	X	X	X	SEMINAR PSM II		
Thesis and Technical Paper Writing										X	X	X	X	X	X	X	X	X			
Prepare for PSM 2 INOTEK															X	X	X				
Prepare for the PSM 2 presentation																X	X	X			
Submission of final draft to supervisor and panels																				X	X
Literature Review						X	X	X	X	X	X	X	X	X	X	X	X	X		X	X

Mark "X" on the Gantt chart for the expected milestones (Hint: Completion of major activities)

Figure 3.26: Project Planning (GANTT CHART)

From figure 3.26, the first three weeks are spent in selecting the title and identify available components. Data collection and research were done to get more information on the project in that three weeks. In the week 3 and week 4, a proposal was propose to the supervisor. According to the supervisor's requirement, the proposal will be adjusted so that it meets the requirement of the Projek Sarjana Muda (PSM)1 subject requirement. While understanding better the project, the input from the panel during proposal defence is also taken into consideration. During week 4 until week 6, the circuit needs to be built on the breadboard and the Arduino code that can send an alarm or notify the presence of mercury needs to be completed. Then the circuit and Arduino code need to be tested and troubleshooted until week 10.

During week 14, the final draft of the technical report was submitted to the supervisor. The report writing was carried out starting week 6, to document every research, action, discussion, and step to complete this project. For the seminar PSM1 in week 14, the slide presentation and the prototype are presented in front of the supervisor and the panels upon video conference. In this session, the question and answer are carried out by the panel base on the understanding of the projects. After that, the project technical report and logbooks of this project are submitted in week 15 to the supervisor as the completion of this PSM1 program.

In the new semester, week 5 until week 13 are spent in thesis and technical paper writing. INOTEK for PSM 2 will be prepared from week 10 to week 12. Then for the seminar PSM2 in week 13, the slide presentation is presented in front of the supervisor and the panels. Lastly, the project technical report and logbooks of PSM2 are submitted in week 16 to the supervisor as the completion of this PSM2 program.

3.6 Cost Analysis

To produce a product, it is vital to know the cost involve as most production and service industries need to know the cost of each product. However, at UTeM, FKEKK students can apply for most of the general components by submitting 'Borang Permohonan Komponen Bahan'. In this project, most of the component is obtained in this way. Table 3.3 shows the cost needed for this project.

Table 3.3: The Cost of this Project

No.	Component	Quantity	Price
1	NodeMCU ESP8266	1	RM17.00
2	PH-4502C sensor module	1	RM28.26
3	Logo-Rnaenaor v2.0 sensor module	1	RM25.05
4	Connecting wires	1	RM5.00
5	PH electrode probe	1	RM21.45
6	Temulawak Cream	1	RM6.50
7	Collagen Cream	1	RM5.00
8	Breylee Cream	1	RM5.85
9	Men's anti-aging cream	1	RM5.76
10	Anfany Cream	1	RM5.72
		Total	RM125.59

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will state the result and the discussion of the result that is obtained. The expected result of this project is to use the Internet of Things to establish a substance detector for mercury in cosmetics. In cosmetics, mercury usually appears as mercury oxide. The pH range is usually between pH 5 and pH 7 [14, 15]. When the pH sensor detects mercury in cosmetics, the pH value data will be sent to the computer or mobile phone through the WiFi module of NodeMCU to send an alarm or notify the presence of mercury.

4.2 Results

4.2.1 The Hardware Connection of The Project

Figure 4.1: The Hardware Connection of The Project with PH-4502C sensor module

Figure 4.1 shows the complete hardware circuit of the project with the PH-4502C sensor module. The connection of the hardware is as follows. The 3.3V pin from NodeMCU is connected to the VCC pin of the pH sensor. The PO pin of the pH-4502C sensor module is connected to pin A0 of the NodeMCU. The ground pin of the sensor module is connected to the ground pin of the NodeMCU.

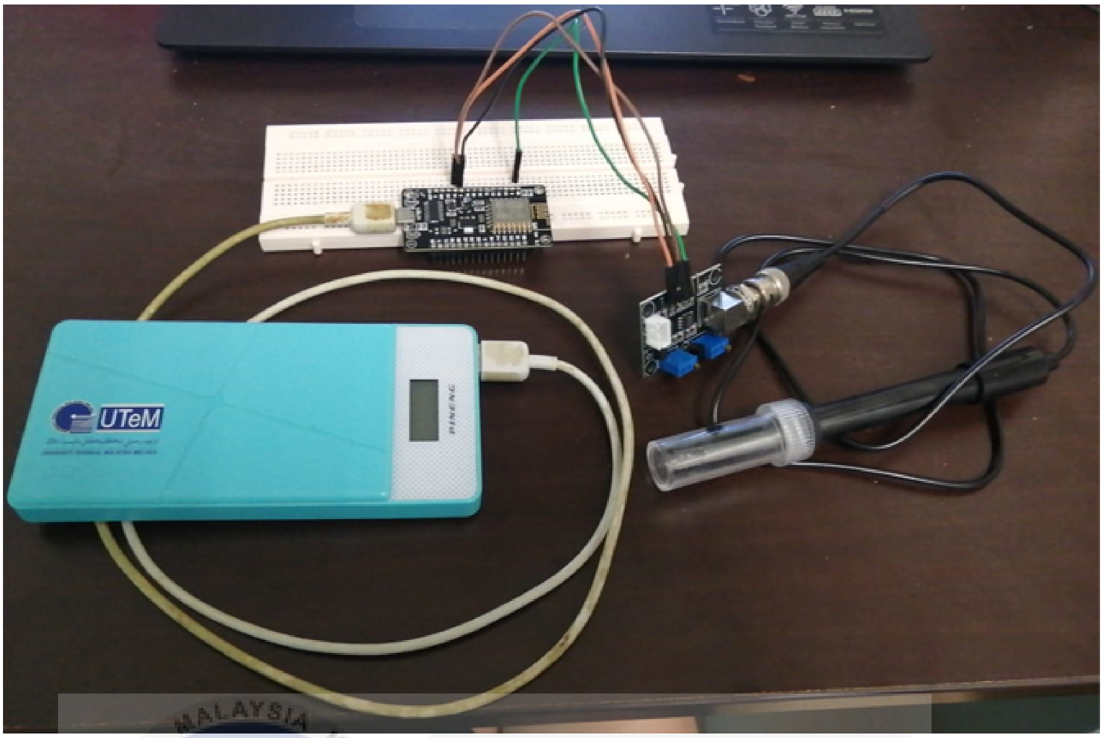
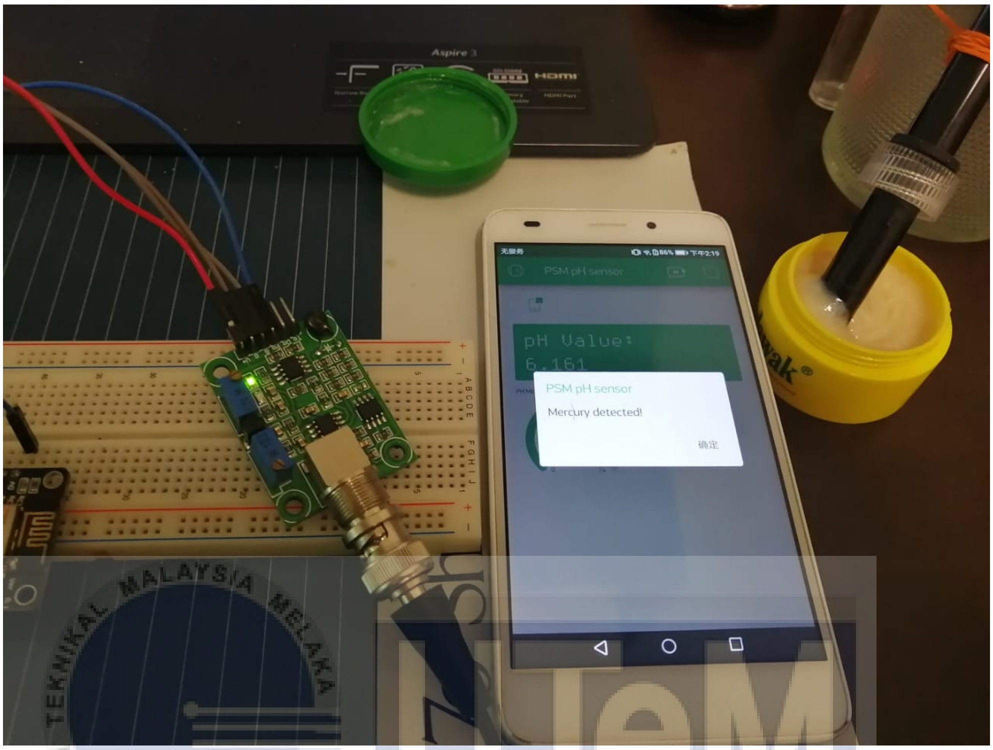


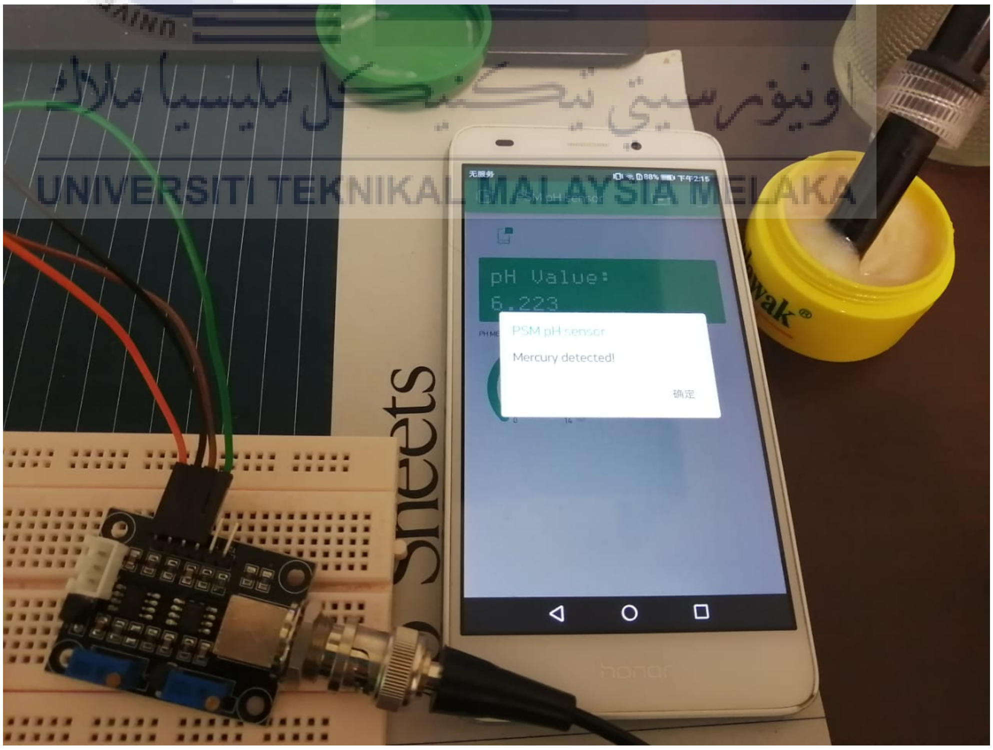
Figure 4.2: The Hardware Connection of The Project with Logo-Rnaenaor v2.0 sensor module

Figure 4.2 shows the complete hardware circuit of the project with the Logo-Rnaenaor v2.0 sensor module. The connection of the hardware is as follows. The 3.3V pin from NodeMCU is connected to the VCC pin of the pH sensor. The PO pin of the Logo-Rnaenaor v2.0 sensor module is connected to pin A0 of the NodeMCU. The ground pin of the sensor module is connected to the ground pin of the NodeMCU.

4.2.2 The Result of Blynk Software

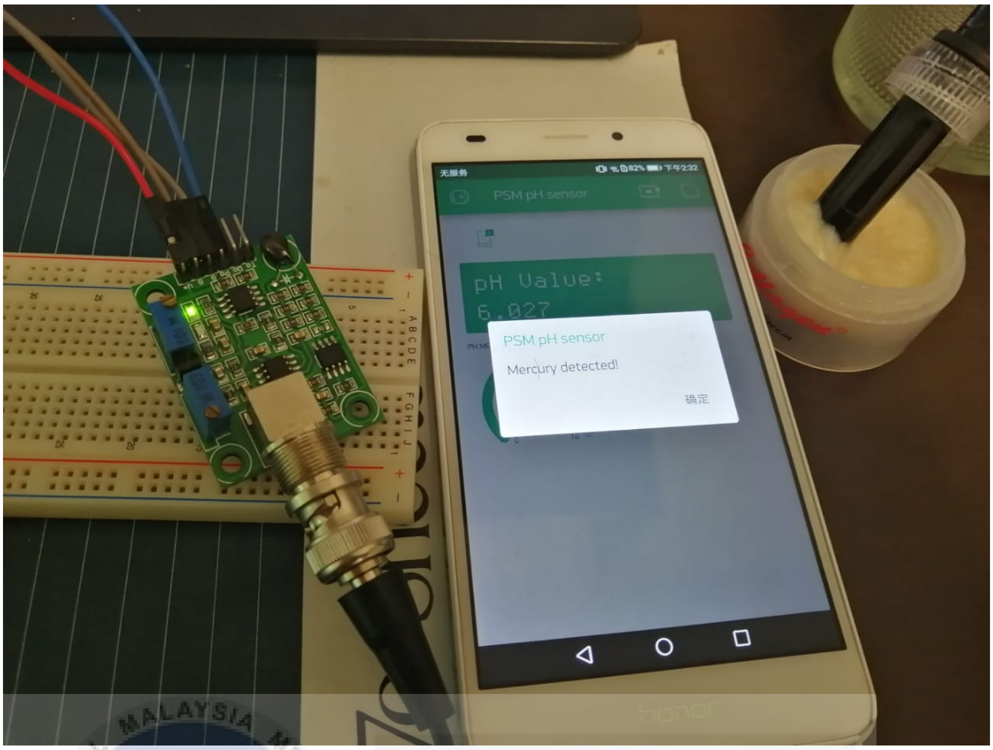


(a) The Result of the PH-4502C sensor module.

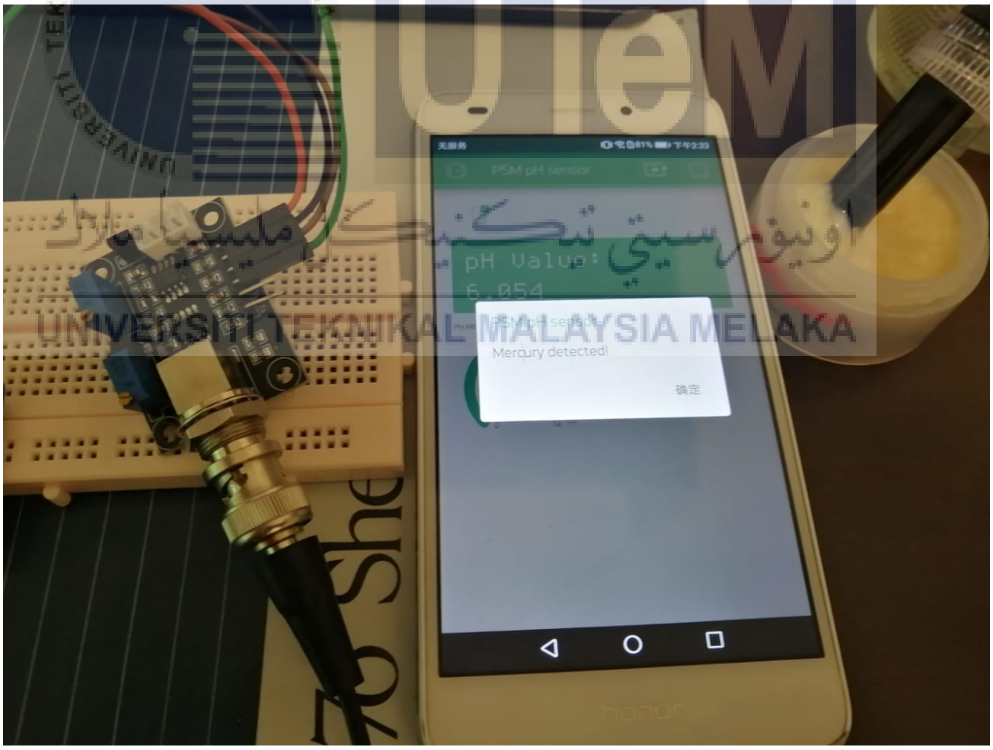


(b) The Result of the Logo-Rnaenaor v2.0 sensor module.

Figure 4.3: Blynk result of Temulawak Cream.

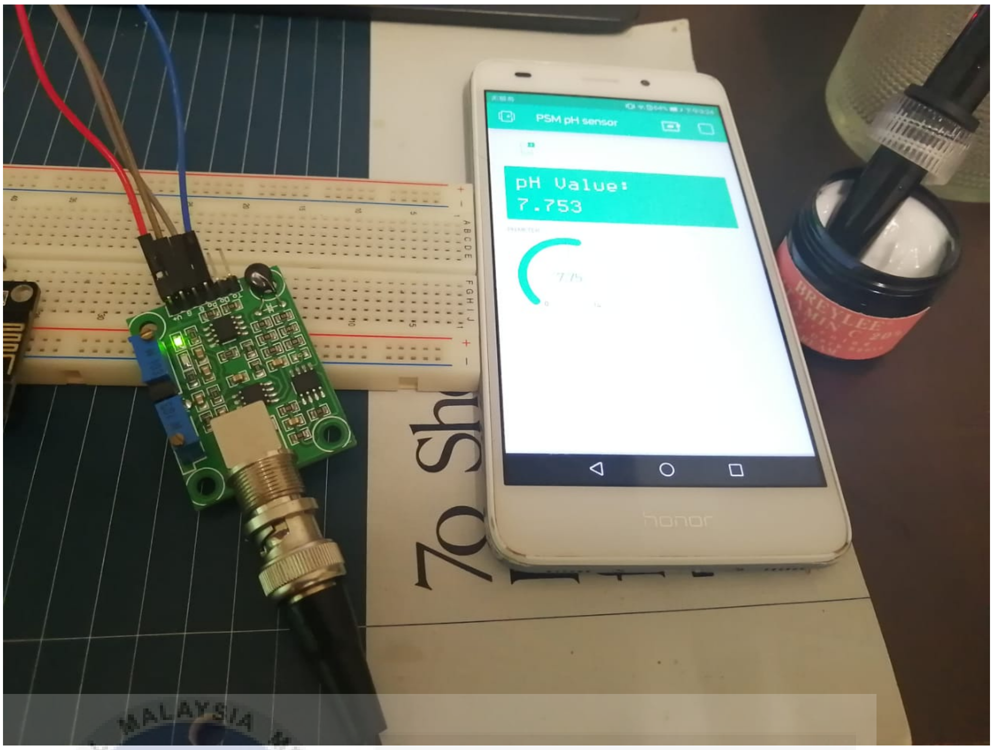


(a) The Result of the PH-4502C sensor module.



(b) The Result of the Logo-Rnaenaor v2.0 sensor module.

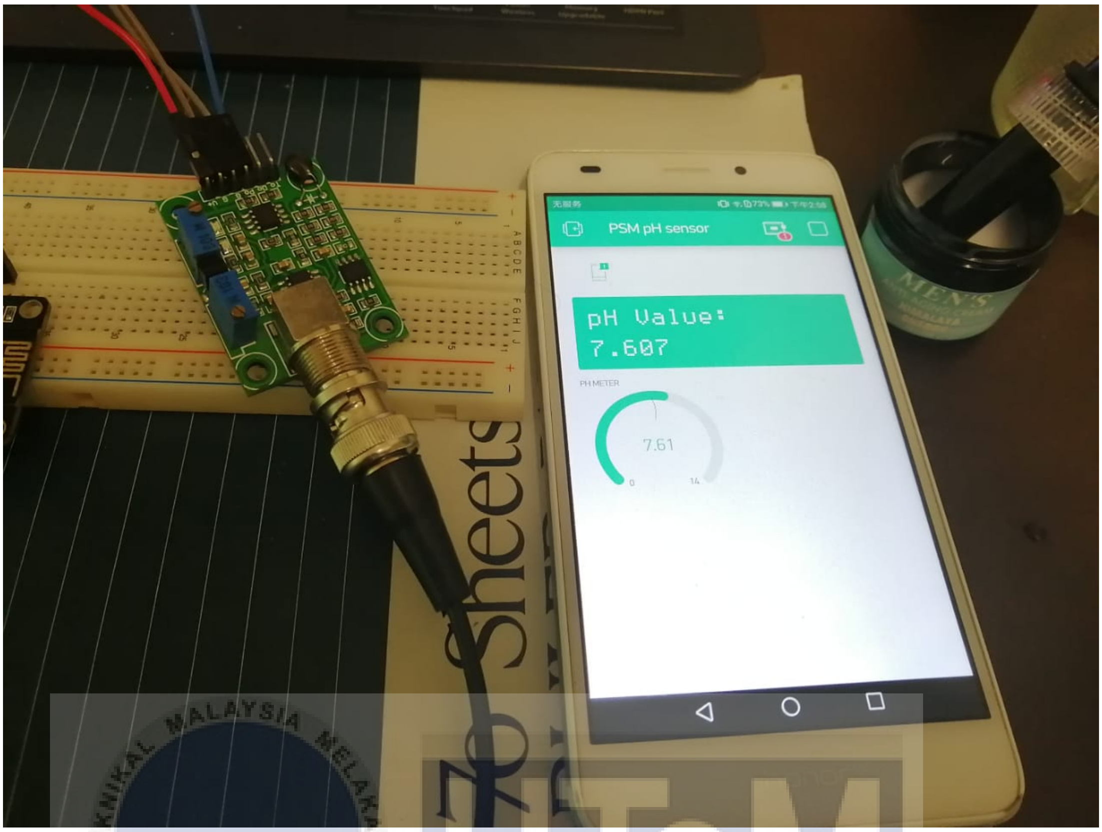
Figure 4.4: Blynk result of Collagen Cream.



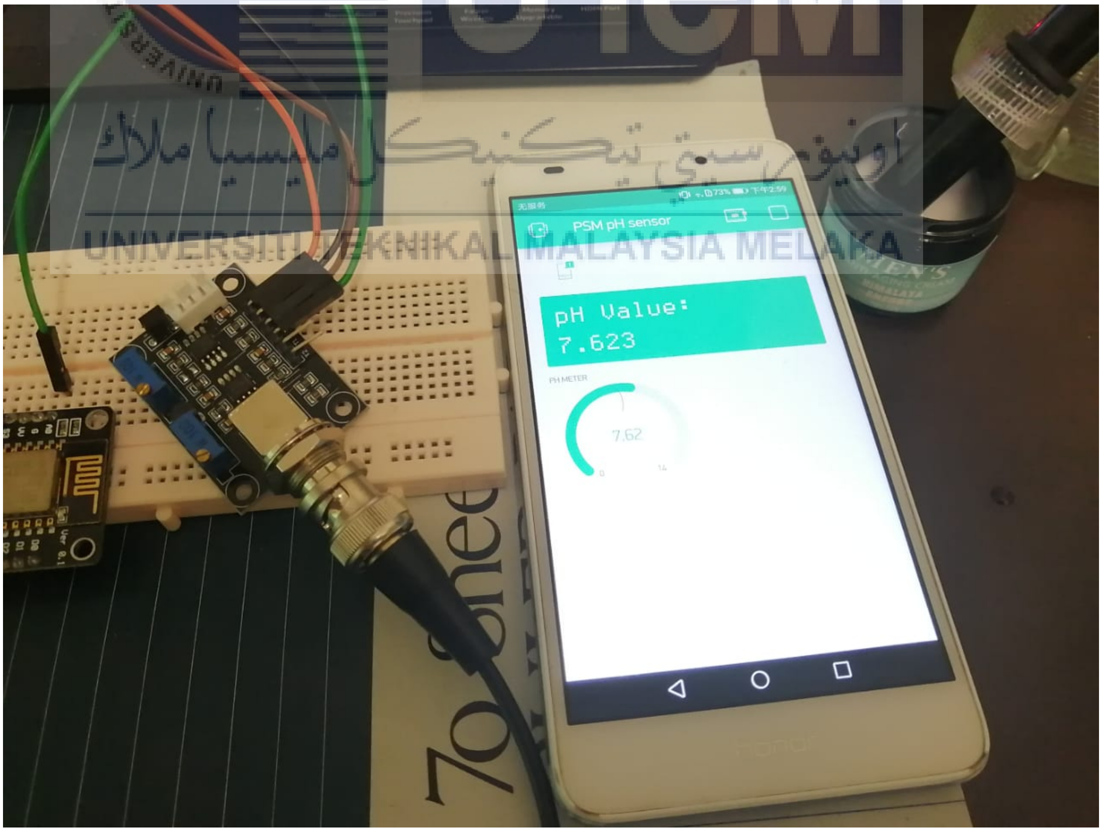
(a) The Result of the PH-4502C sensor module.

(b) The Result of the Logo-Rnaenaor v2.0 sensor module.

Figure 4.5: Blynk result of Breylee Cream.

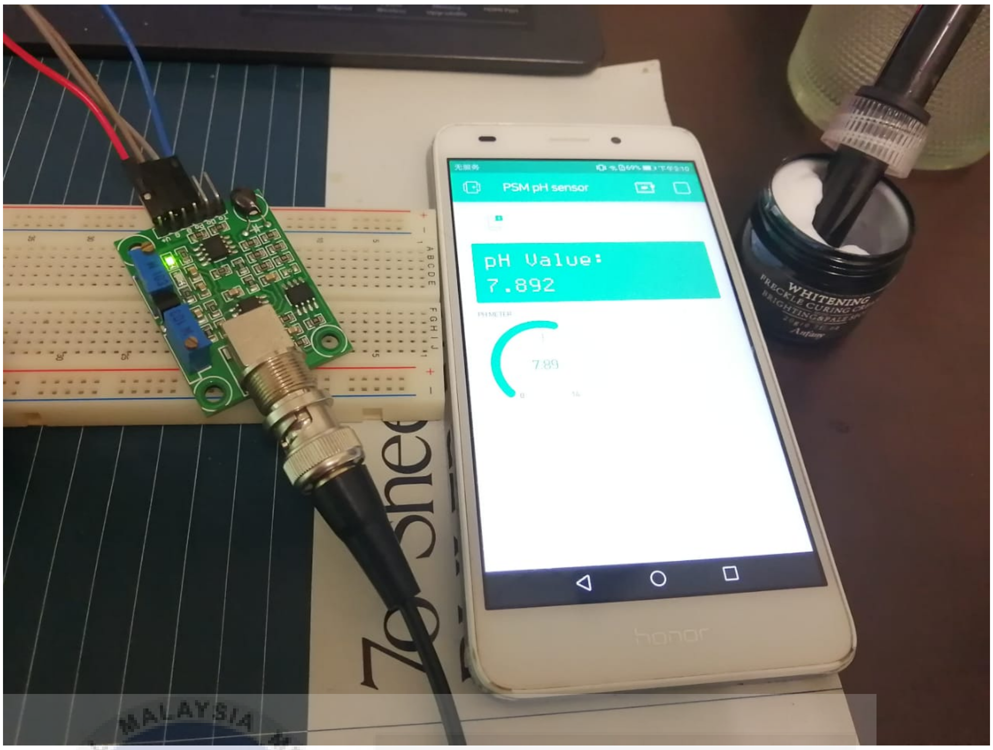


(a) The Result of the PH-4502C sensor module.

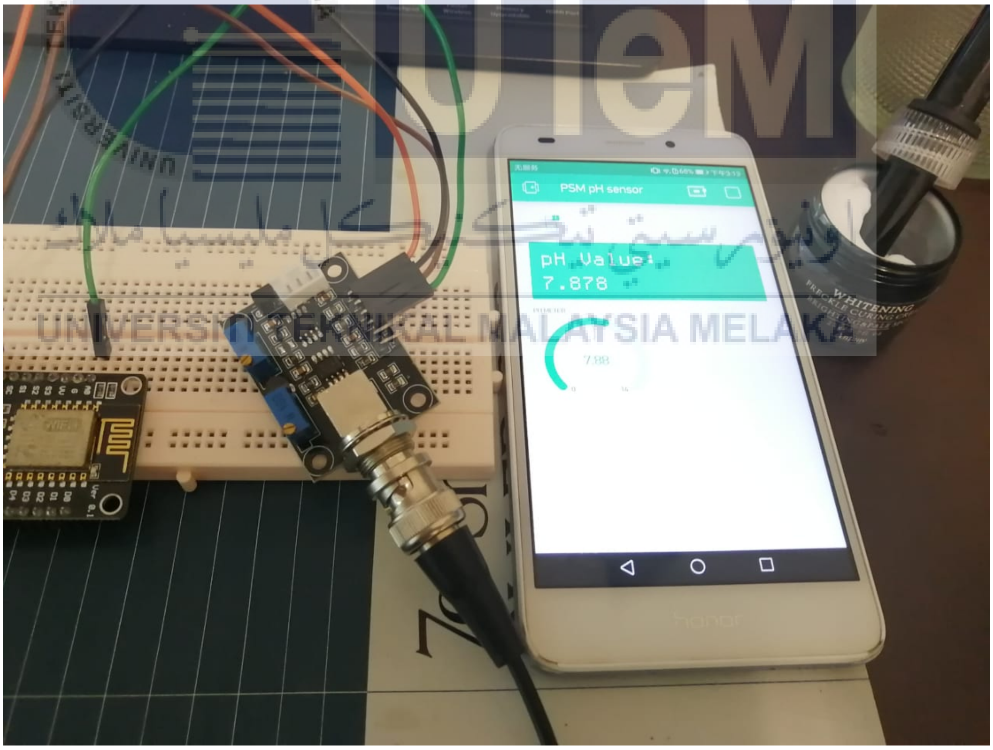


(b) The Result of the Logo-Rnaenaor v2.0 sensor module.

Figure 4.6: Blynk result of Men’s anti-aging cream.



(a) The Result of the PH-4502C sensor module.

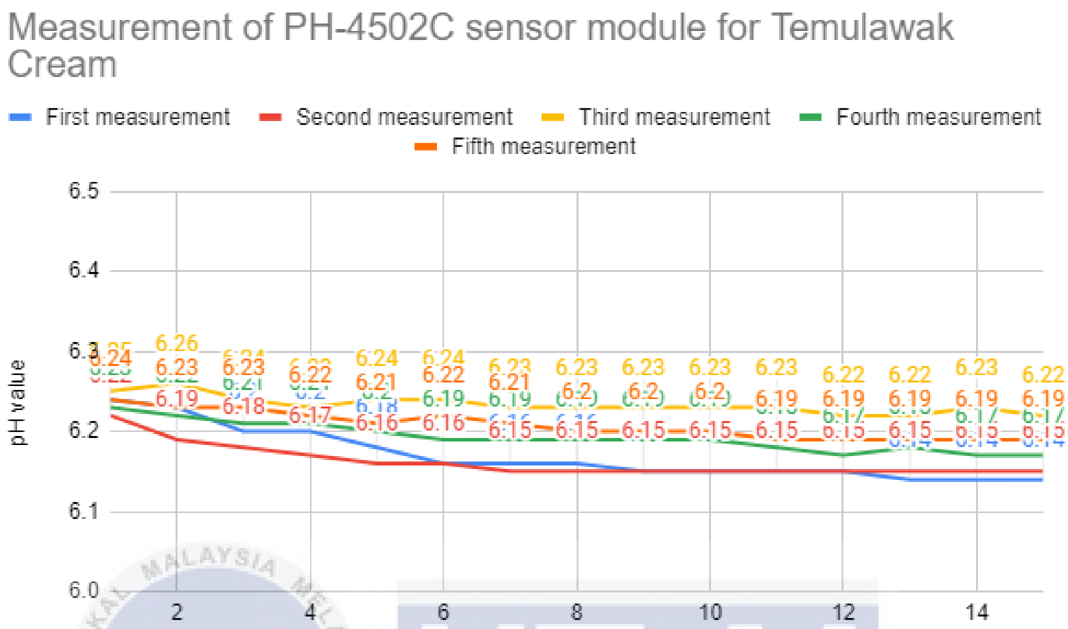


(b) The Result of the Logo-Rnaenaor v2.0 sensor module.

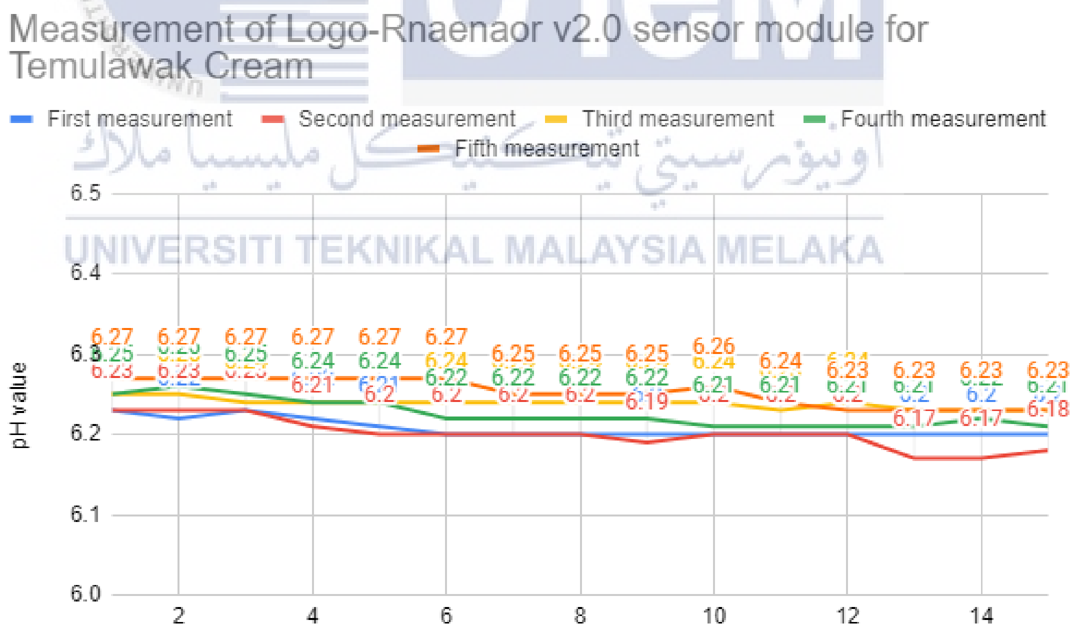
Figure 4.7: Blynk result of Anfany Cream.

Figures 4.3, 4.4, 4.5, 4.6, and 4.7 show the Blynk results of five cosmetic samples. The pH value detected for Temulawak Cream is 6.2; the pH value detected for Collagen Cream is 6.0; the pH value detected for Breylee Cream is 7.8; the pH value detected for Men's anti-aging cream is 7.6; the pH value detected for Anfany Cream is 7.9. In the Arduino IDE software, the pH range of the project code setting to notify the Blynk software of the presence of mercury is pH 5 to pH 7. Therefore, Blynk software notifies the presence of mercury in Figures 4.3 and 4.4. This means that Temulawak Cream and Collagen Cream have detected the presence of mercury; while other creams have not detected the presence of mercury.

4.2.3 Graph of Google Spreadsheet Results

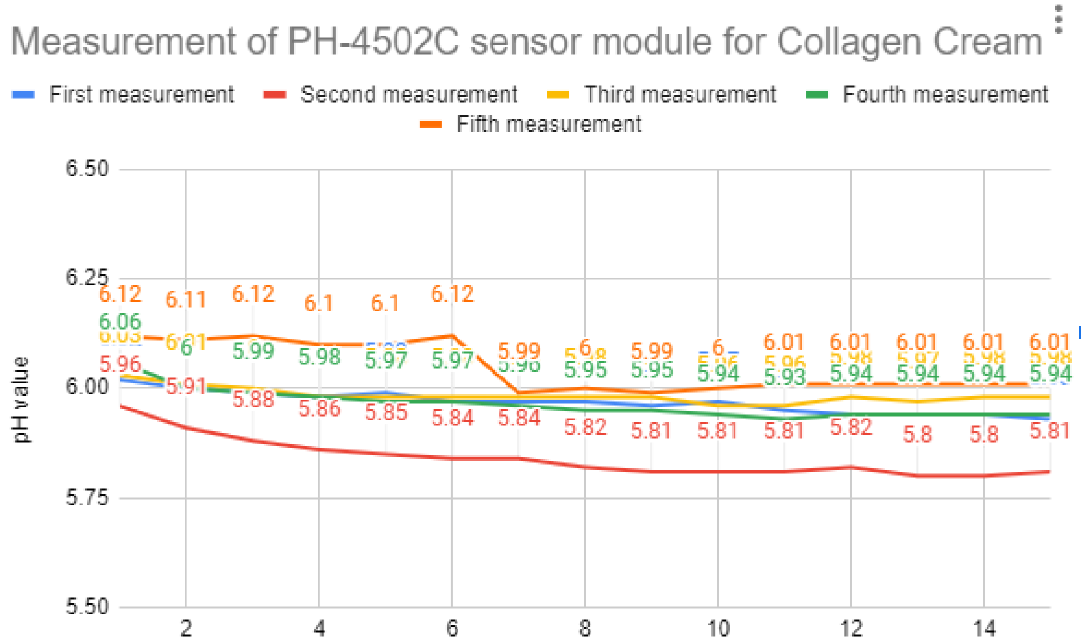


(a) Measurement of PH-4502C sensor module

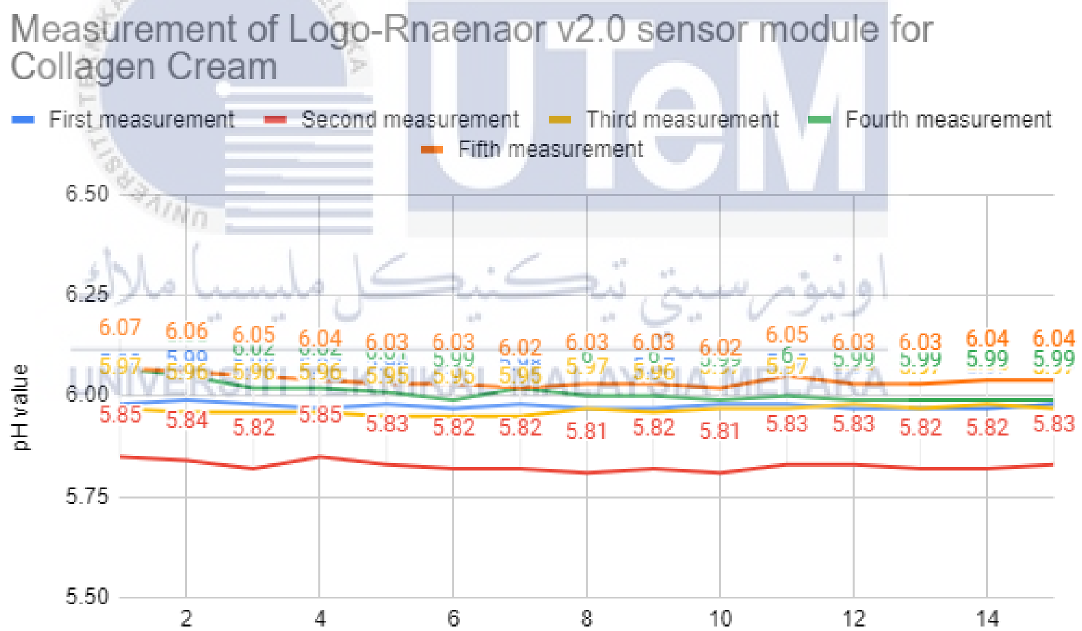


(b) Measurement of Logo-Rnaenaor v2.0 sensor module

Figure 4.8: Measurement for Temulawak Cream

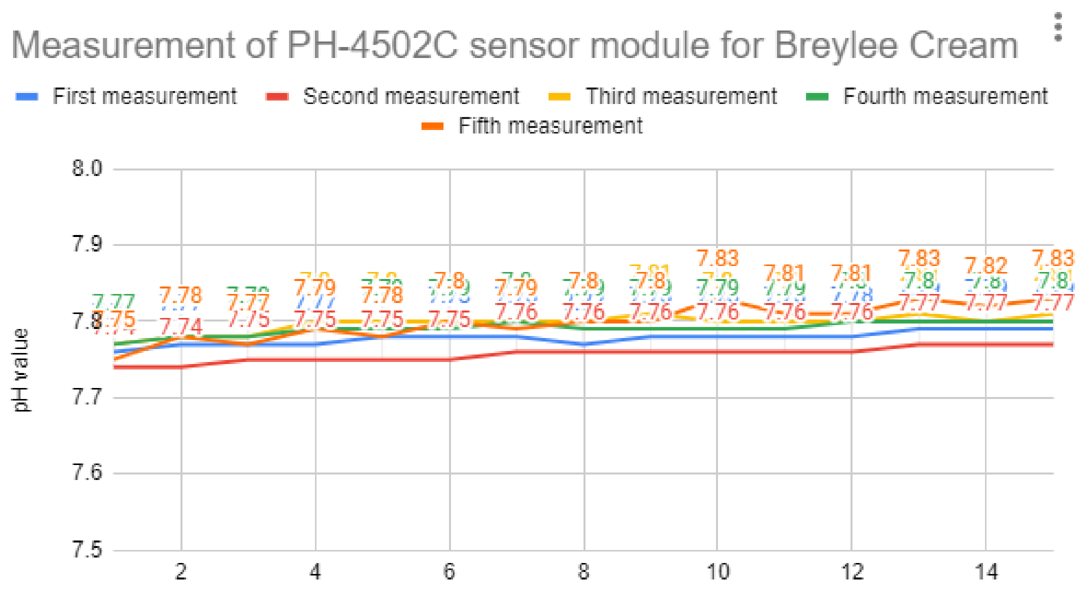


(a) Measurement of PH-4502C sensor module

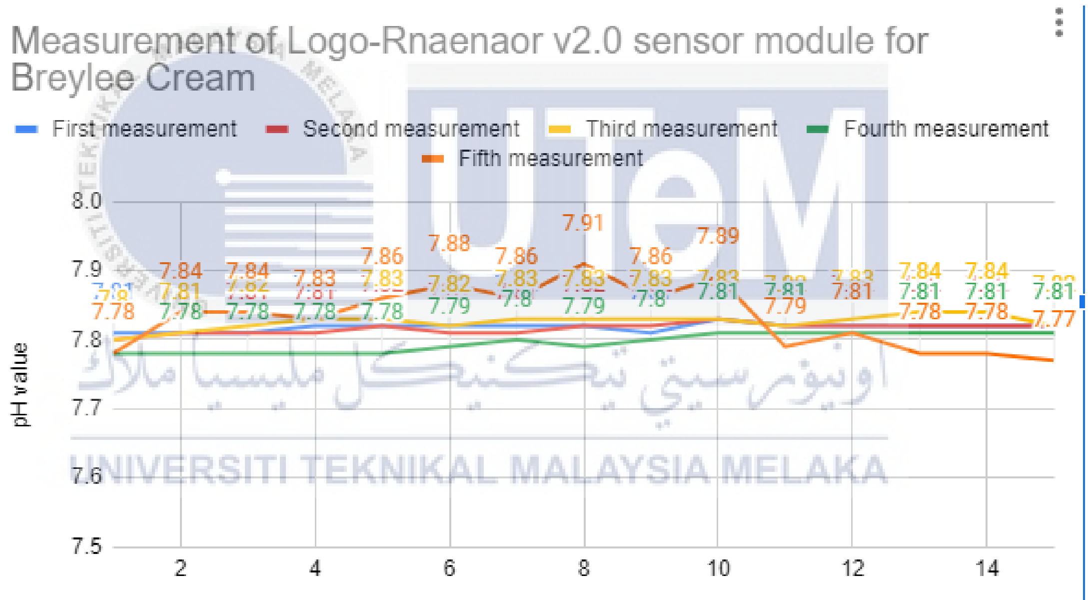


(b) Measurement of Logo-Rnaenaor v2.0 sensor module

Figure 4.9: Measurement for Collagen Cream

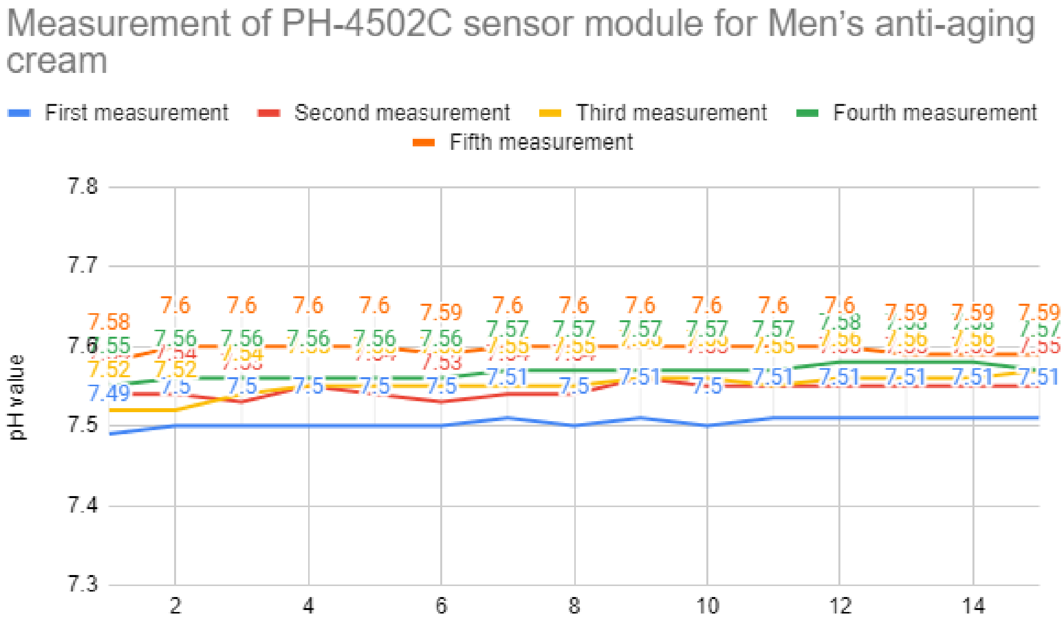


(a) Measurement of PH-4502C sensor module

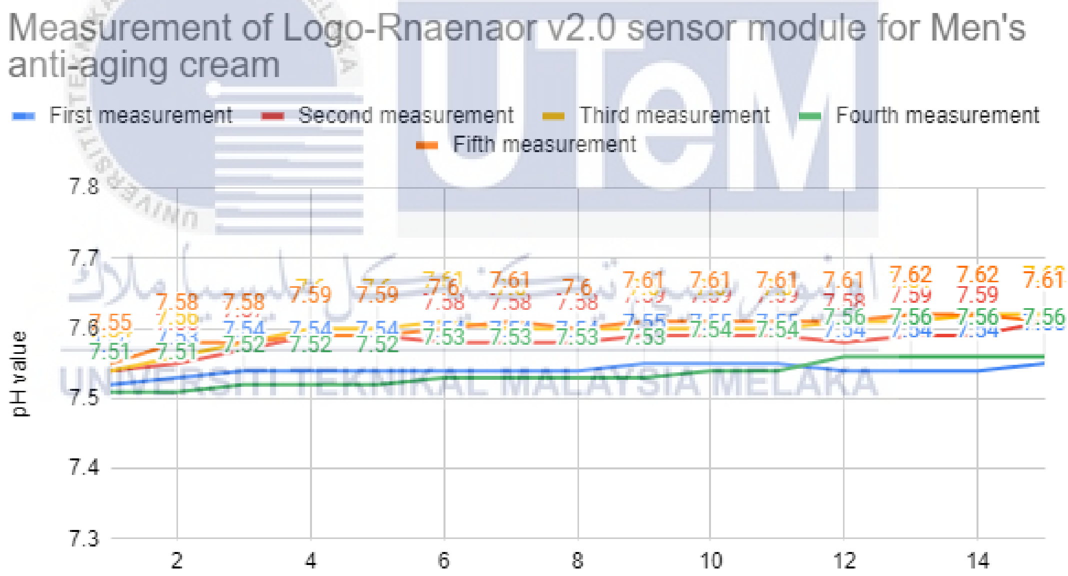


(b) Measurement of Logo-Rnaenaor v2.0 sensor module

Figure 4.10: Measurement for Breylee Cream

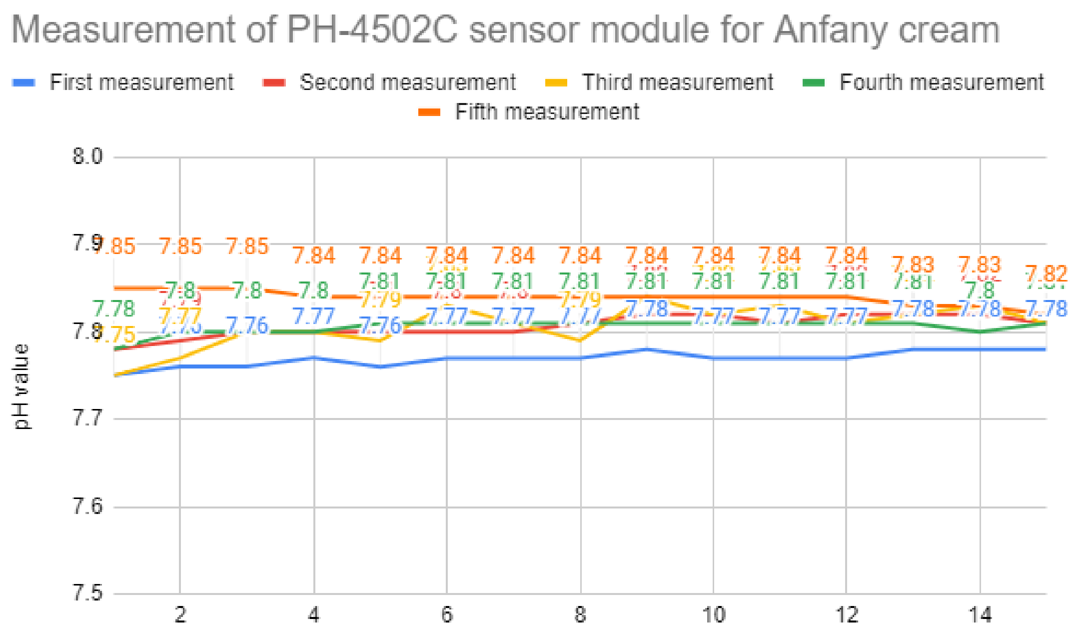


(a) Measurement of PH-4502C sensor module

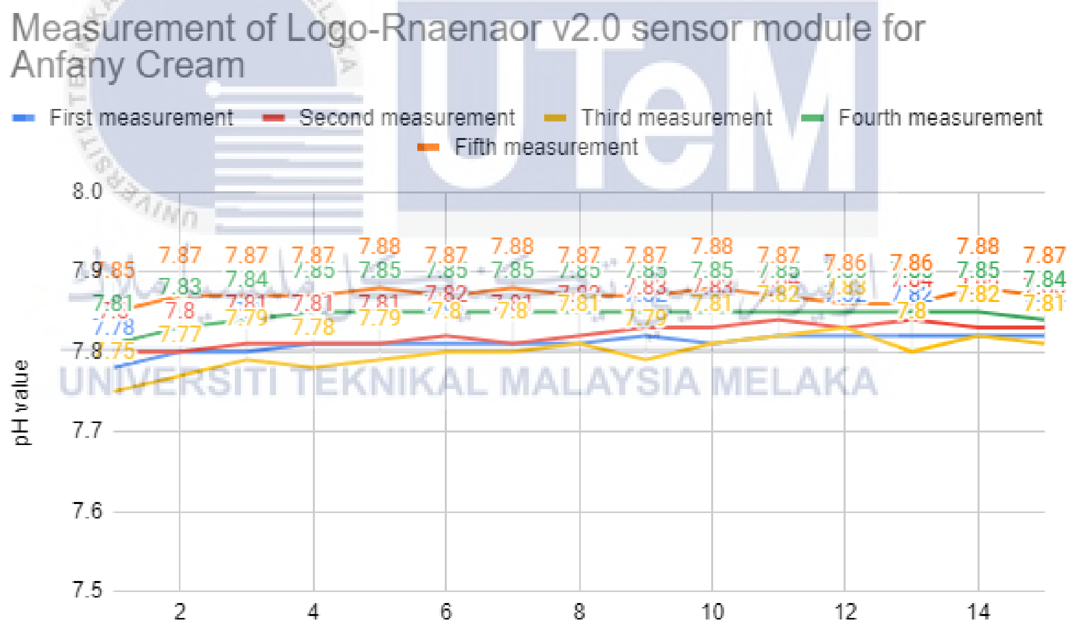


(b) Measurement of Logo-Rnaenaor v2.0 sensor module

Figure 4.11: Measurement for Men's anti-aging cream



(a) Measurement of PH-4502C sensor module



(b) Measurement of Logo-Rnaenaor v2.0 sensor module

Figure 4.12: Measurement for Anfany Cream

Figures 4.8 to 4.12 show the graphs of the five measurement results of the Google spreadsheet for the PH-4502C sensor module and Logo-Rnaenaor v2.0 sensor module. The data detected by each pH sensor will be sent to the Google spreadsheet by NodeMCU. The Google spreadsheet of the project can be opened using a mobile phone or computer via a link. In the Google spreadsheet, the project data will be displayed in more detail. The difference between the five measurement results of the two sensor modules can be seen from the graphs. From Figure 4.8, the measurement results of Temulawak Cream of the two sensor modules are seen to be approximately pH 6.2; the measurement results of Collagen Cream are almost pH 6 shown in Figure 4.9; the measurement results of Breylee Cream and Anfany Cream are higher the pH 7.8 is shown in Figures 4.10 and 4.12; the measurement result of Men's anti-aging cream is almost pH 7.6 is shown in Figure 4.11.

4.2.4 Overall Results

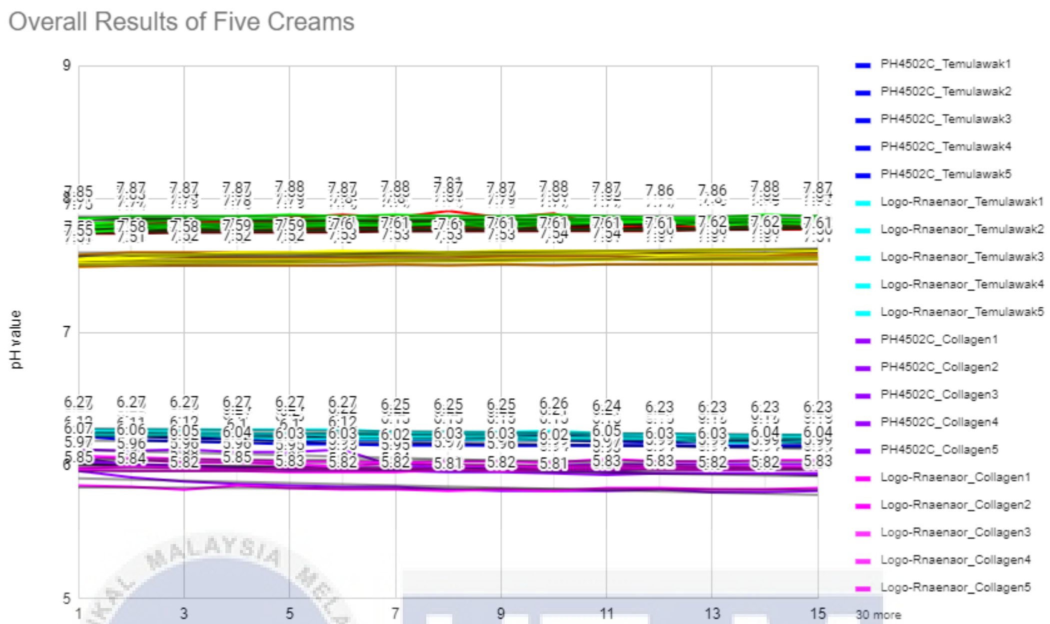


Figure 4.13: Overall Results of Five Creams

Figure 4.13 show the overall results of five cosmetics samples. In the measurement results of Temulawak Cream, the lowest pH value detected by the PH-4502C sensor module is 6.14 and the highest is 6.26; while the lowest pH value detected by the Logo-Rnaenaor v2.0 sensor module is 6.17 and the highest is 6.27. In the measurement results of Collagen Cream, the lowest pH value detected by the PH-4502C sensor module is 5.8 and the highest is 6.12; while the lowest pH value detected by the Logo-Rnaenaor v2.0 sensor module is 5.81 and the highest is 6.07. In the measurement results of Breylee Cream, the lowest pH value detected by the PH-4502C sensor module is 7.74 and the highest is 7.83; while the lowest pH value detected by the Logo-Rnaenaor v2.0 sensor module is 7.77 and the highest is 7.91. In the measurement results of Men's anti-aging cream, the lowest pH value detected by the PH-4502C sensor module is 7.49 and the highest is 7.6; while the lowest pH value detected by the Logo-Rnaenaor v2.0 sensor module is 7.51 and the highest is 7.62. In the measurement results of Anfany Cream, the lowest pH value detected by the PH-4502C sensor module is 7.75 and the highest is 7.85; while the lowest pH value detected by the Logo-Rnaenaor v2.0 sensor module is 7.75 and the highest is 7.88.

4.2.5 The Accuracy of PH Sensor Modules

The accuracy is a measure of the degree of closeness of a measured or calculated value to its actual value. The percent error is the ratio of the error to the actual value multiplied by 100. In this section, the percent error is used to determine which pH sensor module has higher accuracy. The higher the percent error, the lower the accuracy of the pH sensor module. The percentage error formula is shown in equation (4.1).

$$PercentError = \frac{Error}{ActualValue} x100 \tag{4.1}$$

The percent error of the PH-4502C sensor module and Logo-Rnaenaor v2.0 sensor module can be found in Table 4.1.

Table 4.1: The Accuracy of PH Sensor Modules.

Actual pH value of cosmetics	PH-4502C sensor module		Logo-Rnaenaor v2.0 sensor module	
	pH value	Percent Error	pH value	Percent Error
pH6.2	pH6.26	0.97%	pH6.27	1.13%
pH6.0	pH6.12	2%	pH6.07	1.17%
pH7.8	pH7.83	0.38%	pH7.91	1.41%
pH7.6	pH7.6	0%	pH7.62	0.26%
pH7.8	pH7.85	0.64%	pH7.88	1.03%

After comparing the percent error of the PH-4502C sensor module and the Logo-Rnaenaor v2.0 sensor module, it can be found that the most of percent error of the PH-4502C sensor module is less than that of the Logo-Rnaenaor v2.0 sensor module. This means that the accuracy of the PH-4502C sensor module is higher than that of the Logo-Rnaenaor v2.0 sensor module.

4.3 Discussion

The title of this project is IoT Based Detection of Harm Mercury Substances in Cosmetics. This project aims to investigate the relationship between the pH value and the harmful mercury substance in cosmetics. The components used in this project are NodeMCU ESP8266 Board, pH sensor, and connecting wire. In this project, the pH sensor data will be sent by NodeMCU to the Blynk software on the mobile phone in real-time, and the data can be viewed online in a Google spreadsheet.

Before the project started, the circuit of the project was designed and planned from the connection aspect to the offset setting of the pH sensor. The sensor used in this project is the pH sensor. Two pH sensor modules are used in this project, which is the PH-4502C sensor module and the Logo-Rnaenaor v2.0 sensor module. These two sensor modules, like any other sensor that connects to an analog pin, can produce a voltage output to the analog board that represents a PH value. A PH of 0 should represent 0V, and a PH of 14 should indicate 5V. However, these modules have pH 7 set to 0V by default, which means that when reading acidic pH values, the voltage will go into the negatives, which cannot be read by the analog Arduino port. The offset potentiometer in these modules is used to modify this so that a pH 7 will read the expected 2.5V to the Arduino analog pin. The analog pin can read voltages between 0V and 5V, thus the 2.5V is halfway between 0V and 5V, much like a PH 7 is halfway between PH 0 and PH 14. In order to connect the sensor module with the NodeMCU, the 3.3V pin of the NodeMCU is connected to the VCC pin of the pH sensor. The PO pin of the pH sensor module is connected to pin A0 of the NodeMCU. The ground pin of the sensor module is connected to the ground pin of the NodeMCU.

After the hardware connection is complete, it's time to focus on the software part of the coding. Before entering the coding part, the project needs to set the software setting used in the project. The Arduino IDE software needs to install Blynk Library and ESP8266 Add-on to run related functions. In the Blynk software, the project needs to create a Blynk project to obtain the Auth Token of the Blynk software so that it can be added to the Arduino code. In the Google spreadsheet, a Google ID was created so that the link can be added to the Arduino code. To send data to Google Spreadsheet, the coding of Google script was done in the tab Script editor of Google Spreadsheet. After finishing the coding of the Google script, it is published, and Deploy as a web app was clicked. Under Deploy as a web app, enter Project version as the function and select ‘anyone, even anonymous’ for access to the app, click on the Deploy icon. It will ask for permission, therefore, permission is given by clicking on the ‘Give permission’ icon. After successfully giving permission, the web URL was given. This URL will be used in the Arduino coding.

Next, the Arduino Code of the project will be uploaded into the NodeMCU microcontroller. A test run of the system will be done to detect any bug in the project. After some troubleshooting with the hardware, the system runs smoothly. When the sensor detects the mercury substances in cosmetics, it will start sending notifications to the Blynk software to notify the presence of mercury. In addition, the sensor data will also be sent to Google spreadsheet, and the project’s historical detection data can be viewed through Google spreadsheets. From Arduino Code, the coding ‘Blynk.notify("Mercury detected!");’ is used to notify the Blynk software of the presence of mercury; and the URL of Google Spreadsheet is used to send the sensor data to the Google spreadsheet.

In this project, five skin whitening creams were used as cosmetic samples, including Temulawak Cream, Collagen Cream, Breylee Cream, Men’s anti-aging cream, and Anfany Cream. The pH values detected by the two pH sensor modules used in this project are almost the same, but usually, the pH value detected by the Logo-Rnaenaor v2.0 sensor module is a little higher than the pH value detected by the PH-4502C sensor module. The pH value detected for Temulawak Cream is almost pH6.2; the pH value detected for Collagen Cream is almost pH6; the pH value detected for Breylee Cream is almost 7.8; the pH value detected for Men’s anti-aging cream is almost 7.6; the pH value detected for Anfany Cream is almost 7.8. In this project, the pH range where the presence of mercury is detected is from pH5 to pH7. This means that Temulawak Cream and Collagen Cream have detected the presence of mercury; while other creams have not detected the presence of mercury.

Several problems occurred during running the test. The first is the offset setting of the sensor. During the first project running test, the sensor cannot detect the pH value correctly because the pH-4502C sensor module used in the project sets pH 7 to 0V by default. After troubleshooting the problem by adjusting the offset potentiometer on the sensor module, the problem is solved and the sensor sets pH 7 to 2.5V. The next problem is the google spreadsheet used in the project fails to receive the data from the NodeMCU. This took a few days to troubleshoot the problems. After the problem had been identified, the steps taken to solve it was edited the coding in the google script and test with the URL that was generated. After the URL had been tested and can function perfectly, the URL then will insert into the Arduino coding, the run test has run again to make sure the data can send to the google spreadsheet of the project. The last problem that occurred during the running test was the time shown in the database. In the database of the system, there are some details about the time and the date to make the user feel easy to collect the data. While the database is collecting the data, the time shown in the database was different from the time during testing. After troubleshooting, the cause was identified which was the coding in google script. The time variable of the coding had been changed to 'GMT+8' instead of 'MYR time'. For the information, 'GMT+8' is the Malaysia time zone. This means that the system can be used in any country as long as the time zone changed to a specific country's time zone.

This project also has limitations. The limitation of this project is that the mercury in cosmetics detected by the pH sensor may not be accurate enough. The pH value of mercury substances in cosmetics is about pH5 to pH7. The current pH setting of the project is to send an alarm or notify the presence of mercury data to a mobile phone or computer when pH5 to pH7 is detected. However, substances with pH values of pH5 to pH7 are not limited to mercury substances in cosmetics. This means that when other substances with pH values of pH5 to pH7 are detected, false alarms or notifications will be sent. Therefore, this project may require multiple different sensors to more accurately detect mercury in cosmetics.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Introduction

This chapter provides an overall summary of the development and implementation of the IoT Based Detection of the Harm Mercury Substance in Cosmetics. The future work section describes the recommendations that can be considered to enhance the developed and implemented IoT Based Detection of the Harm Mercury Substance in Cosmetics.

5.2 Conclusion

In conclusion, this thesis is documented based on the development and implementation of the IoT Based Detection of the Harm Mercury Substance in Cosmetics. When this project detects mercury in cosmetics, the data from the detector will notify the presence of mercury through the Blynk software. The historical detection data of the detector can be viewed through the Google spreadsheet.

The development of this project is based on the Internet of Things. NodeMCU is equipped with an ESP8266 WIFI module. This project used NodeMCU's ESP8266 WIFI module to send data to Blynk software and Google spreadsheets through the Internet of Things.

This project mainly detects the presence of mercury by detecting the pH value of mercury substances. The pH setting for detecting mercury-containing substances is based on the research outlined by U. Ekpunobi (2014) and M. Arshad (2021). These two studies show that the pH value of most mercury-containing cosmetics is acidic, so this project is set the pH range from pH 5 to pH 7.

In this project, when the pH range set by the project is detected, the ESP8266 Wifi module of NodeMCU will send a notification to the Blynk software of the presence of mercury via the Internet of Things. Then the data of the pH sensor will be stored in the Google spreadsheet.

By comparing the pH-4502C and Logo-Rnaenaor v2.0 sensor modules, if only the PH detection range is considered, the two sensor modules are the same, but considering the percent error of the two sensor modules, the accuracy of the PH-4502C sensor module is higher than the Logo-Rnaenaor v2.0 sensor module. This means that the PH-4502C sensor module is a better choice to detect harmful mercury substances in cosmetics.

At the end of this project, the application of this project is huge. It can not only be used to detect the pH value of mercury in cosmetics but also can be used for soil measurements in agriculture, water quality for municipal water supplies, swimming pools, environmental remediation; brewing of wine or beer; manufacturing, healthcare, and clinical applications such as blood chemistry; and many other applications.

5.3 Future Works

In future work, the project may need to add other types of sensors to help pH sensors more accurately detect mercury in cosmetics. Because substances with pH values of pH5 to pH7 are not limited to mercury in cosmetics, adding other sensors that can help detect mercury, the results will be more accurate. The sensor suggested here is a TDS sensor.

The current detection standard for cosmetics is that the mercury content is less than 1 ppm. However, there is currently no sensor for the Arduino board that can directly detect the mercury content in cosmetics based on ppm units. In the future, it is possible to develop a sensor for Arduino board based on ppm unit that can directly detect mercury in cosmetics, but it cannot be resolved at present.

This project has a lot to do with sustainability and environmental friendliness. This project can be used for water quality monitoring and is suitable for the determination of the pH value of drinking water, surface water, groundwater, and sewage. This can intuitively understand the water quality, whether the residual chlorine content exceeds the standard; whether the acidity and alkalinity are normal; whether the minerals such as copper and iron exceed the standard.

REFERENCES

[1] N. A. Bohari, S. Siddiquee, S. Saallah, M. Misson, and S. E. Arshad, "Electrochemical behaviour of real-time sensor for determination mercury in cosmetic products based on pani/mwcnts/aunps/ito," *Cosmetics*, vol. 8, no. 1, p. 17, 2021.

[2] H. H. Abbas, M. Sakakibara, K. Sera, E. Andayanie *et al.*, "Mercury exposure and health problems of the students using skin-lightening cosmetic products in makassar, south sulawesi, indonesia," *Cosmetics*, vol. 7, no. 3, p. 58, 2020.

[3] P. D. Selid, H. Xu, E. M. Collins, M. Striped Face-Collins, and J. X. Zhao, "Sensing mercury for biomedical and environmental monitoring," *Sensors*, vol. 9, no. 7, pp. 5446–5459, 2009.

[4] N. A. Bohari, S. Siddiquee, S. Saallah, M. Misson, and S. E. Arshad, "Optimization and analytical behavior of electrochemical sensors based on the modification of indium tin oxide (ito) using pani/mwcnts/aunps for mercury detection," *Sensors*, vol. 20, no. 22, p. 6502, 2020.

[5] R. Sukesan, Y.-T. Chen, S. Shahim, S.-L. Wang, I. Sarangadharan, and Y.-L. Wang, "Instant mercury ion detection in industrial waste water with a microchip using extended gate field-effect transistors and a portable device," *Sensors*, vol. 19, no. 9, p. 2209, 2019.

[6] T. Minami, T. Minamiki, and S. Tokito, "Detection of mercury (ii) ion in water using an organic field-effect transistor with a cysteine-immobilized gold electrode," *Japanese Journal of Applied Physics*, vol. 55, no. 4S, p. 04EL02, 2016.

[7] W. Xiao, M. Xiao, Q. Fu, S. Yu, H. Shen, H. Bian, and Y. Tang, "A portable smart-phone readout device for the detection of mercury contamination based on an aptamer-assay nanosensor," *Sensors*, vol. 16, no. 11, p. 1871, 2016.

[8] Q. Fu, Z. Wu, F. Xu, X. Li, C. Yao, M. Xu, L. Sheng, S. Yu, and Y. Tang, "A portable smart phone-based plasmonic nanosensor readout platform that measures transmitted light intensities of nanosubstrates using an ambient light sensor," *Lab on a Chip*, vol. 16, no. 10, pp. 1927–1933, 2016.

[9] J. Chang, G. Zhou, X. Gao, S. Mao, S. Cui, L. E. Ocola, C. Yuan, and J. Chen, "Real-time detection of mercury ions in water using a reduced graphene ox-

ide/dna field-effect transistor with assistance of a passivation layer," *Sensing and bio-sensing research*, vol. 5, pp. 97–104, 2015.

[10] J. Chen, "Real-time, selective detection of lead ions in water using a graphene-based field-effect transistor sensing platform," in *ECS Meeting Abstracts*, no. 28. IOP Publishing, 2017, p. 1316.

[11] M. Talat, P. Tripathi, and O. N. Srivastava, "Highly sensitive electrochemical detection of mercury present in the beauty creams using graphene modified glassy carbon electrode," *Innovations in Corrosion and Materials Science (Formerly Recent Patents on Corrosion Science)*, vol. 8, no. 1, pp. 24–31, 2018.

[12] M. Ghanei-Motlagh, M. A. Taher, A. Heydari, R. Ghanei-Motlagh, and V. K. Gupta, "A novel voltammetric sensor for sensitive detection of mercury (ii) ions using glassy carbon electrode modified with graphene-based ion imprinted polymer," *Materials Science and Engineering: C*, vol. 63, pp. 367–375, 2016.

[13] M. Guo, J. Wang, R. Du, Y. Liu, J. Chi, X. He, K. Huang, Y. Luo, and W. Xu, "A test strip platform based on a whole-cell microbial biosensor for simultaneous on-site detection of total inorganic mercury pollutants in cosmetics without the need for predigestion," *Biosensors and Bioelectronics*, vol. 150, p. 111899, 2020.

[14] U. Ekpunobi, E. Okonkwo, C. Udeh, A. Ogbuagu, and C. Duru, "Determination of hydroquinone and mercury concentrations in some skin lightening lotions and creams sold in southeastern nigeria," *International Journal of Biotechnology Research*, vol. 2, no. 1, pp. 011–016, 2014.

[15] M. Arshad, Y. Sadef, M. B. Shakoor, M. Naeem, F. Bashir, S. R. Ahmad, S. Ali, I. Abid, N. Khan, and M. N. Alyemeni, "Quantitative estimation of the hydroquinone, mercury and total plate count in skin-lightening creams," *Sustainability*, vol. 13, no. 16, p. 8786, 2021.