UNIVERSITI PUTRA MALAYSIA

AN IoT-BASED MONITORING AND CONTROLLING SYSTEM FOR IRRIGATION AND FERTILIZATION UNDER PLANT FACTORY

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ABSTRACT

Malaysia is one of the largest producer of fresh vegetables in Asia. A collection of ground formation and suitable weather all the time enable our country to achieve sustainable food production in Agricultural sector. In order to increase the quality and the efficiency of the crop production, precision agriculture and modern technology is needed to develop and encourage among the vegetable producers. Precision agriculture can provides higher yields with a lower input cost and environmental pollution compared with traditional method used. Instead of using labor to carry out the activities, precision agriculture relies more on latest computer and electronic technologies which could simplify the works. One of the example is IoT system. IoT is a network of physical objects (i.e. devices, vehicles, and buildings) instrumented with embedded electronics, sensors, software, and networking connectivity enabling these objects to collect and exchange data. In this project, an IoT System with four sensor (temperature, pH, turbidity and humidity) is developed and the data is directly displayed on the screen of smart phone. Arduino and Blynk software is used to link between each other and the data obtained show an accurate results. This system is very useful for farmer to detect the actual amount of fertilizer and water needed by plant or crops.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In Malaysia, urban population is expected to increase 75% by the year 2020 (MITI,2015. Urban residents are facing increasing living costs particularly due to rising cost of food production, processing and distribution. In 2014, the cost of imported processed food rise to RM 17 billion compared to RM 8.97 billion in 2012 (MITI, 2015). One of the goals of the National Agro-Food Policy (NAFP) is to ensure adequate supply of safe and quality food for the entire nation in Malaysia. In order to achieve these, urban agriculture is viewed as a way through which the livelihood strategies of urban households can be addressed. A number of government institutes and organizations have begun to encourage urban residents to participate in urban agricultural activities such as the department of agriculture (DOA) and Malaysian Agricultural Research and Development Institute (MARDI). Every government agencies are very concern about the sustainable food provided in their own country. Many improvement had been done in agricultural sector in order to increase the production of crop. One of the example is precision agriculture in plant factory.

Precision agriculture can provides higher yields with a lower input cost and environmental pollution compared with traditional method used (Shirish and Bhalerao,2013). Instead of using labor to carry out the activities, precision agriculture relies more on latest computer and electronic technologies (Cho,2012, Zaks and Kucharik, 2011). In accordance to this, decision support systems have been developed in order to provide the expert information and knowledge needed for farmers in the agricultural management. In (Rossi et al. 2014), grapevine farmers make the right decision to practice the pesticide treatment on the right time with the help of an author who expert in using software tools that consist of analysis for basic parameters in the vineyard such as air , soil, plants, pests and so on.

In recent years, the development of information and communication technology (ICT) resulted in the emergence of two important concepts that affect the world which is Internet-of-Thing (IoT) and cloud computing (Evans, 2011, Mell and Grance,2011). Both concepts are expected to be put to use in agriculture on a much larger scale (Vermesan and Friess, 2013, Kaloxylos, 2012). The IoT is a network of physical objects (i.e. devices, vehicles, and buildings) instrumented with embedded electronics, sensors, software, and networking connectivity enabling these objects to collect and exchange data (Ojha et al., 2015). The IoT equips objects of interest to be sensed and controlled remotely over existing and future network infrastructure, which creates various opportunities to integrate physical objects with computer-based systems. The main goals of IoT include improved efficiency, accuracy, economic gains, and better quality of life (Holler, 2014). Cloud computing is based on the utilization of computer resources (processors, memory, storage, network), which can be located and managed remotely. Cloud computing service models include infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS). Clouds can be deployed as public, private, or hybrid (Mell and Grance, 2011). Our goal is to implement a private IoT cloud platform that can be used as a foundation for research and development in the domains of precision agriculture and ecological monitoring. The mission of the project is to create a research and development platform in the areas of sustainable agriculture, monitoring of the crops, forest and water ecosystems, development of techniques for controlling and reducing pollution, analysis and standardization of food products, control of land quality, and improvement of the public health. The project is focusing on the utilization of IoT and Cloud to support the adoption of these novel technologies and innovations in the areas of precision agriculture and ecological monitoring.

1.2 PROBLEM STATEMENT

Majority of vegetable planted producer in Malaysia comes from rural area.The level of education among them is very low and they learn to plant by try an error and based on their own or other's experiences. They don't know the right technique, the suitable amount of fertilizer needed, the time for irrigation and the efficiency way to solve the problem. Most of the skills and technologies used among them are traditional which need a larger amount of labor and time with a lower production of crop compared to modern farming.

The polluted environment and changed climate recently have increase the challenges of farmer to manage their crops for disease and pest infestation. As we know, bad quality of environmental condition is the favorite place for the growth of pathogens and virus. To overcome the problem, farmers need to spray more pesticides and fungicides to make sure the crops free from disease. This is not a suitable way to solve the problem but increase the input cost and degrade the quality of crops. Under several factors, our countries suffered from insufficient vegetable supplies every year and imported food from other countries is necessary to overcome the problem. Malaysia paid lots of money to other countries just for imported vegetable products.

Hydroponic systems, such as the deep flow technique, nutrient film technique, or aeroponic systems, are essential tools in plant factories. For adequate management of water and nutrients in the hydroponic system, the electrical conductivity (EC), pH, dissolved oxygen, and temperature should be measured. Because ion concentrations in the nutrient solutions change with time, resulting in a nutrient imbalance in closed hydroponic systems, real-time measurements of all nutrients are required, but such measurements are not available due to technical problems. Periodic analysis of nutrient solutions and adjustment of nutrient ratios can improve the nutrient balance.

Existing IoT system with sensor for determination of water quality has limitation in function. It just uses to read the data only. Another continuous action needed to carry out by farmers themselves is do it manually. This lower the efficiency of the progress of agricultural activities.

Thus, efficient control system is needed to increase the productivity of crop and reduce the reliable on other countries. The application of IoT would be helpful and important in development of agriculture sector among the farmers.

1.3 AIMS AND OBJECTIVES OF THE STUDY

The aim of this project is to develop an IoT-based monitoring and controlling system for fertilization under plant factory. The specific objectives are as following:

- To develop an IoT system of the proposed design that connected to the smart phone
- To validate the data collected in smart phone with the data measured by devices

1.4 SCOPE OF THE STUDY

This study as conducted in the plant factory structure developed by Macro Agriculture S/B located in Cameron Highlands, Pahang. The size of the structure is very large which occupied 10 acre spaces. The crops sample used is green coral. The plant factory is set up with the complete equipment including hydroponic irrigation system, ventilation system, and circulation piping system. Nutrient solution used in this hydroponic solution is collected as sample for testing.

There are some apparatus needed to prepare to carry out the project, for example thermometer, pH meter, Iot Board, Sensor,and phone apps named Blynk, All these things need be to connect with each other especially Iot Board, sensors and phone with Blynk apps. Some coding needed to put inside the Iot system in order to transfer the information directly to the phone. The basic parameter of nutrient solution needed to be measured is pH value, humidity, temperature, and turbidity value and flow rate of water. The reading are recorded into a smart phone and ready to validate with the reading measured by using devices.

CHAPTER 2

LITERATURE REVIEW

2.1 PLANT FACTORY WITH HYDROPONIC SYSTEM

A plant factory is a commercial plant-growing facility. These facilities are closed growing systems that allow farmers to have a constant production of crops throughout an entire year. When a farmer is growing within a plant factory, aspects such as light, moisture, carbon dioxide, and temperature can be controlled. Plants grown in plant factories are often grown vertically in hydroponic systems. Plant factories are considered by many to be the future of farming. Growing methods such as vertical farming and the growing implementation of urban agriculture have increased the interest and investment for plant factories and related technology. Additionally, it is thought that plant factories can provide a more efficient way to provide food for the world's growing population.

Plant factories are often high-tech and highly automated. They are able to produce crops year-round as opposed to traditional growing methods that are dependent on growing seasons. Additionally, plant factories are exceedingly efficient as they can yield up to four times faster and 20 times more than traditional, open-field agriculture.

Other benefits of plant factories are that more crops can be grown locally, or crops can even be grown at home with smaller versions. Additionally, plant factories allow crop quality to be controlled and constantly monitored. (Eriel Danna, 2016).

2.2 INTRODUCTION OF IOT SYSTEM

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect, collect and exchange data (Brown, Eric,2016).

IoT involves extending Internet connectivity beyond standard devices, such as desktops, laptops, smartphones and tablets, to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled. With the arrival of driverless vehicles, a branch of IoT, i.e. the Internet of Vehicle starts to gain more attention (Umar Zakir Abdul, Hamid; et al. 2019).

2.3 SMART PLANT FACTORY BY USING IOT SYSTEM IN AGRICULTURE

Plant factory farming is a methodology that helps in enhancing the yield of vegetables, fruits, crops etc. It control the environmental parameters through manual intervention or a proportional control mechanism. As manual intervention results in production loss, energy loss, and labor cost, these methods are less effective. A smart plant factory can be designed with the help of IoT; this design intelligently monitors as well as controls the climate, eliminating the need for manual intervention. For controlling the environment in a smart plant factory, different sensors that measure the environmental parameters according to the plant requirement are used. We can create a cloud server for remotely accessing the system when it is connected using IoT. This eliminates the need for constant manual monitoring. Inside the greenhouse, the cloud server also enables data processing and applies a control action. This design provides cost-effective and optimal solutions to the farmers with minimal manual intervention.

Many organization uses new modern technologies for providing services. It builds modern and affordable greenhouses by using solar powered IoT sensors. With these sensors, the greenhouse state and water consumption can be monitored via SMS alerts to the farmer with an online portal. Automatic Irrigation is carried out in these greenhouses. The IoT sensors in the greenhouse provide information on the light levels, pressure, humidity, and temperature. These sensors can control the actuators automatically to open a window, turn on lights, control a heater, turn on a mister or turn on a fan, all controlled through a WiFi signal.(Holler, 2014).

2.4 IMPORTANT OF WATER IN AGRICULTURE

Farming accounts for around 70% of water used in the world today and also contributes to water pollution from excess nutrients, pesticides and other pollutants. But the competition for water is increasing and the costs of water pollution can be high.

Increased pressure from urbanisation, industrialisation and climate change will provide agriculture with more competition for water resources and climate change could affect water supply and agriculture through changes in the seasonal timing of rainfall and snow pack melt, as well as higher incidence and severity of floods and droughts.

Sustainable management of water in agriculture is critical to increase agricultural production, ensure water can be shared with other users and maintain the environmental and social benefits of water systems. Governments need to improve the economic efficiency and environmental effectiveness of policies that seek to improve water resource use efficiency and reduce water pollution from agricultural systems.(OECD, 2014)

Regular water testing can give you useful knowledge about the safety of water and how it might vary during the season or from year to year. Water testing labs test for E. coli instead of Salmonella spp., Listeria monocytogenes, hepatitis A virus, parasites, and other sources of human illness because it can be a useful indicator of these and other pathogens.

Growers who sell their produce through wholesale markets may be required to test their water as a condition of sale. Contact your buyers to make sure you understand their testing requirements. The Food Safety Modernization Act will require water testing for produce growers regulated under the law (PennState Extention, 2013)

In order to produce a good quality of crop, water controlling must be concerned with the basic parameter such as pH value, EC value, dissolved oxygen, temperature, nutrient content and etc (citation??)

2.5 EFFECT OF WATER TEMPERATURE TO THE GROWTH OF PLANTS

Current personal knowledge on the subject is minimal (plants need water and sun). However, minimal thinking brings the obvious to mind – plants do not "care" about the temperature of water, just as long as it is received. Researched materials show that plants, specifically the roots, can actually be damaged by extremely hot or cold water. But there was no research on how it would affect a seed attempting to grow. Research shows that the environmental has temperature has more of an effect on plant growth than water temperature. Extreme environmental temperatures cause the plants to develop at a faster rate, but are those same temperatures are detrimental to the reproductive stage in a plant life cycle. Therefore, water temperature does not affect plant growth.(Jordan Huffman,2015)

When irrigate the plants, it is essential to use water at the right temperature. This is because the roots of your plants are very sensitive to extremes of temperature. Using water that is too hot or too cold can put your plant under stress and cause damage. The optimum temperature for roots to absorb water and nutrients is around 68°F. At that temperature, the water in the substrate still contains a lot of oxygen, and it is also exactly the right temperature to trigger the pump mechanism in the roots. At lower temperatures, the pump mechanism will not work as effectively, while at higher temperatures the plant is less able to take up oxygen from the water. Additionally, higher temperatures and a lack of oxygen can cause an increase in harmful moulds (such as Pythium) and bacteria, and all the problems that associated with those. (Canna,2018)

2.6 EFFECT OF WATER PH TO THE GROWTH OF PLANTS

The growth of plants can be affected by the pH of nutrient solution. Bacteria change and release nitrogen from organic matter and some fertilizer is optimum when pH value is between 5.5- 7.0. Plant nutrient leach much faster when pH value below than 5.5 and some of mineral like aluminum can be dissolved into toxic material when pH value lower than 5. The growth of plant is prohibited and the risk getting infection is increasing. So, pH value can be also affect the availability of plants nutrients. All nutrient of plant is optimum in 5.5- 7.0 pH value. Although the optimum range is 5.5-7.0 but some plant will growth in more acidic medium and some will growth in more alkaline medium.(Katherine Rosenberg-Douglas, May 2106)

2.7 EFFECT OF TURBIDITY TO THE GROWTH OF PLANTS

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. The higher the value of turbidity, the lower the quality of water. High value of turbidity reduce the oxidation agent inside the water and having harmful impacts to the plants and crops. Crop planting with high value of turbidity resulted a higher risk for getting infection, and abnormal growth of plant.(Minnesota Pollution Control Agent, March 2018)

2.8 EFFECT OF HUMIDITY TO THE GROWTH OF PLANTS

Humidity is the amount of water vapor in the air. Too much or too little humidity can be dangerous. For example, high humidity combined with hot temperatures is a combination that can be a health risk, especially for the very young and the very old. Humidity plays an important role in our daily weather. Without water vapor in the air, our weather might be like the weather on Mars. Every homeowner should own a hygrometer that measures temperature and relative humidity (RH). The ideal relative humidity for health and comfort is about 40 - 50%. In the winter months, it may have to be lower than 40% RH to avoid condensation on the windows.(Therma-Stor,2019)

CHAPTER 3

METHODOLOGY

3.1 PROCEDURE OF THE STUDY

Figure below shows the overview of steps involved in the procedure of the study. Each Step will be further discussed in detail throughout this chapter.

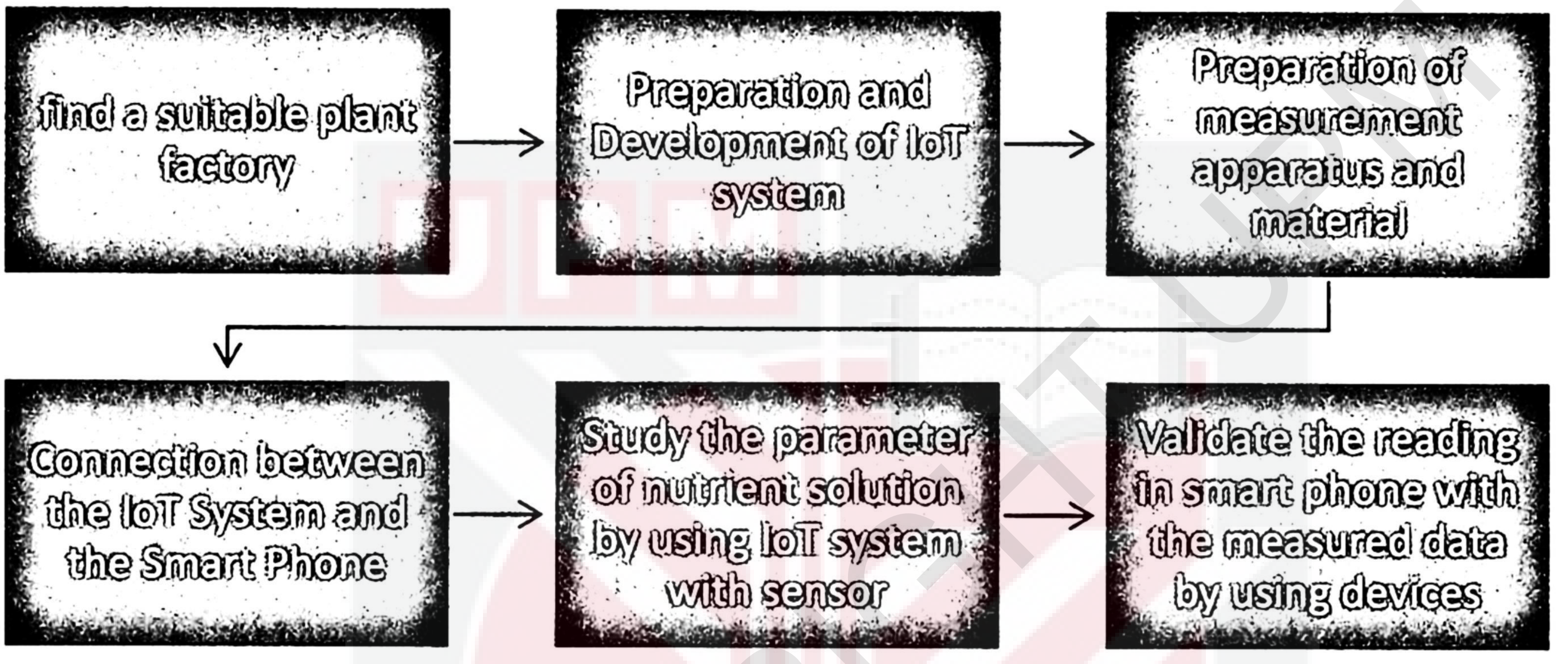

Figure 1: The Flow Chart of Methodology

3.2 FIND A SUITABLE PLANT FACTORY

A suitable plant factory with complete equipment is found in MARDI, Serdang where is nearby UPM. The transportation cost and time can be saved due to the short distance. Another Plant Factory chosen for carry out the experiment is located in Cameron Highlands named Macro Agriculture S/B which experienced in hydroponic farming at least 5 years.

3.3 PREPARATION AND DEVELOPMENT OF IOT SYSTEM

All the IoT system and sensor materials is bought from a supplier in the south city mall named MY ROBOT EDUCATION. A breadboard, Arduino Uno, connecting wire, temperature sensor, ph value sensor, turbidity sensor, humidity sensor, power supply and microcontroller, Arduino software and an App named Blynk is needed to develop IoT system. The data measured by the sensor is recorded in smart phone via WIFI signal.

Figure 2: Microcontroller

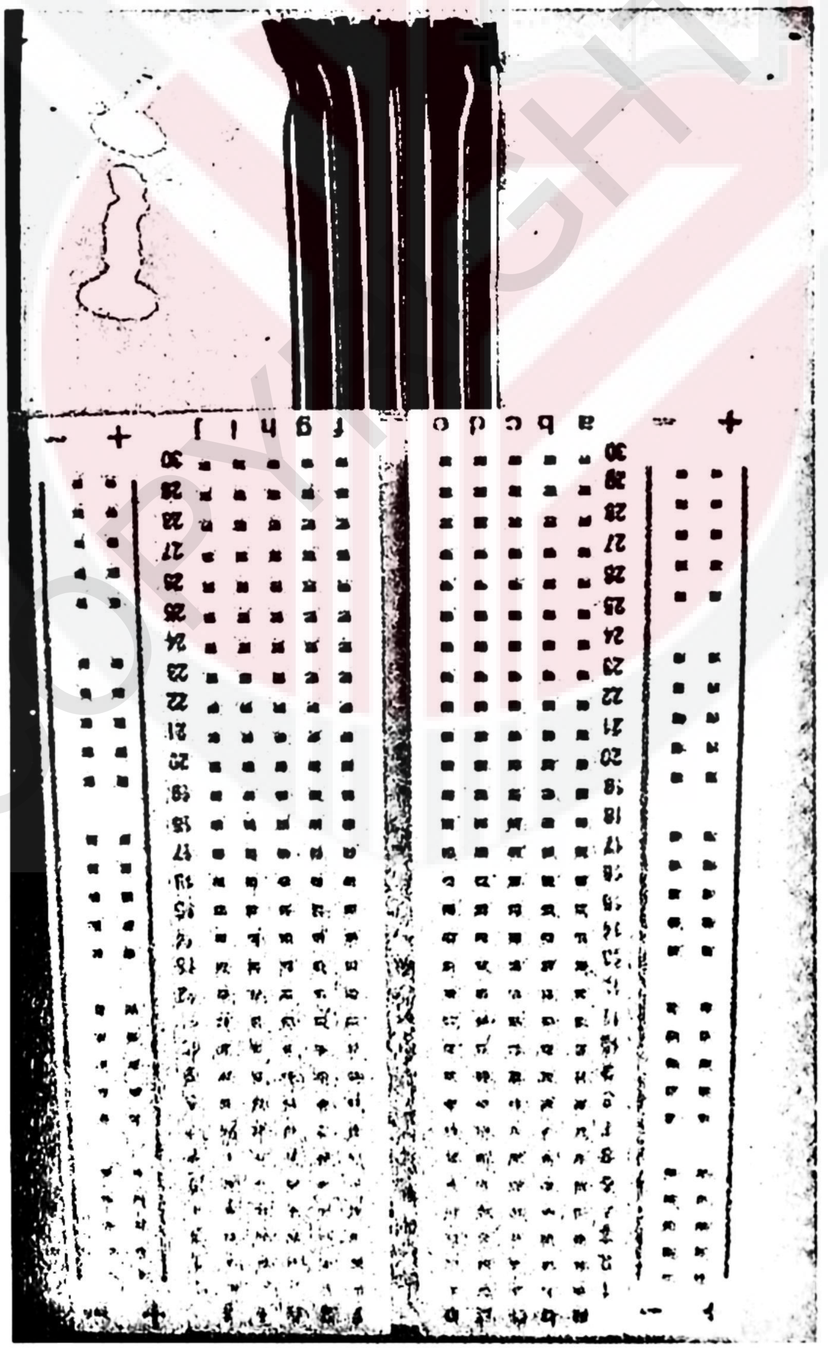

Figure 4 : Breadboard

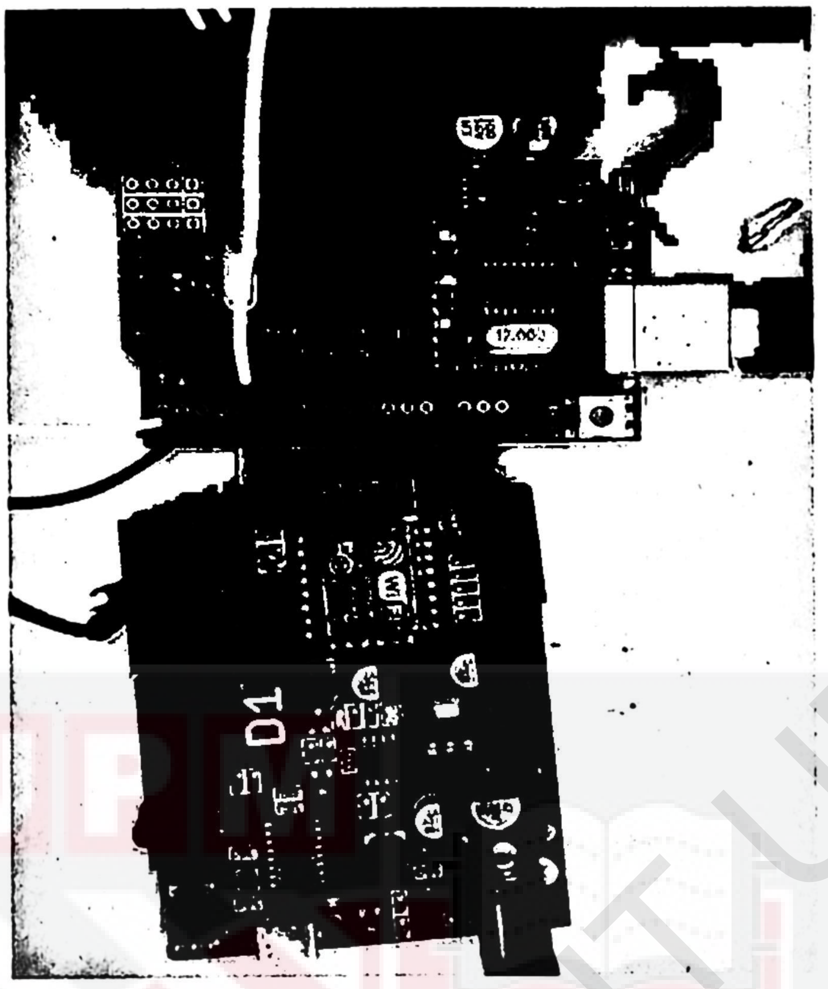

Figure 5: Arduino Uno

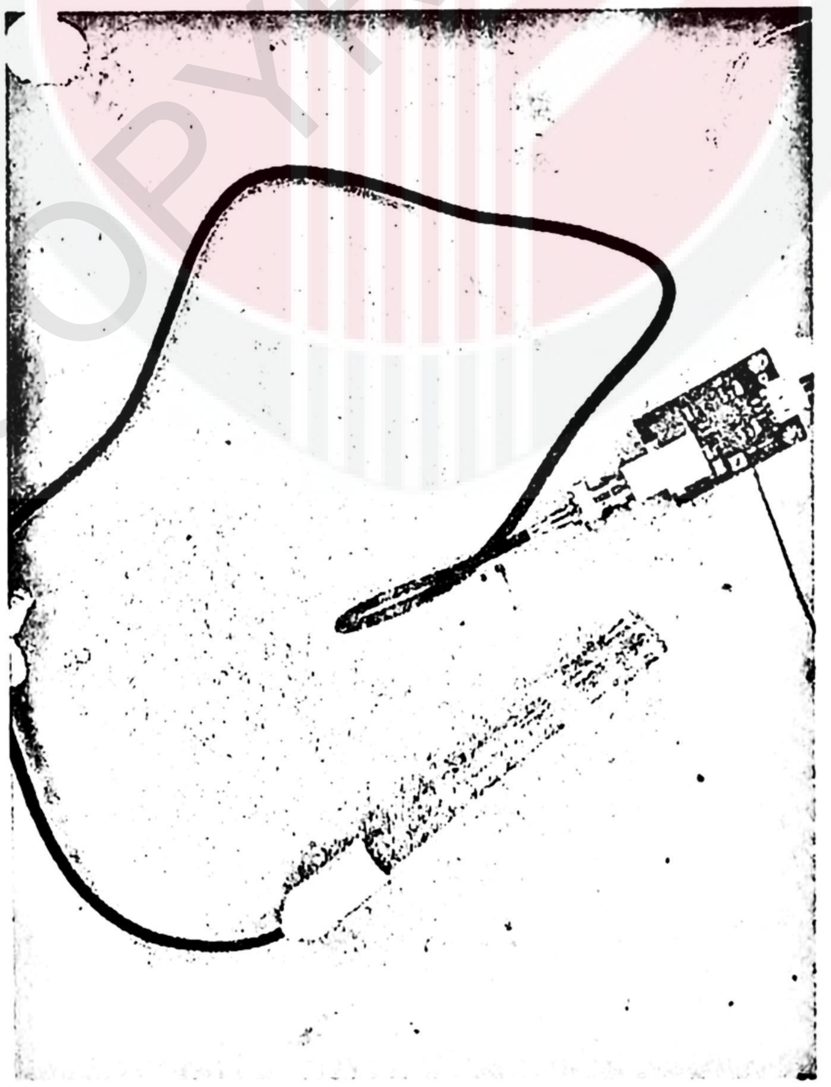

Figure 6: pH and Temperature Sensor

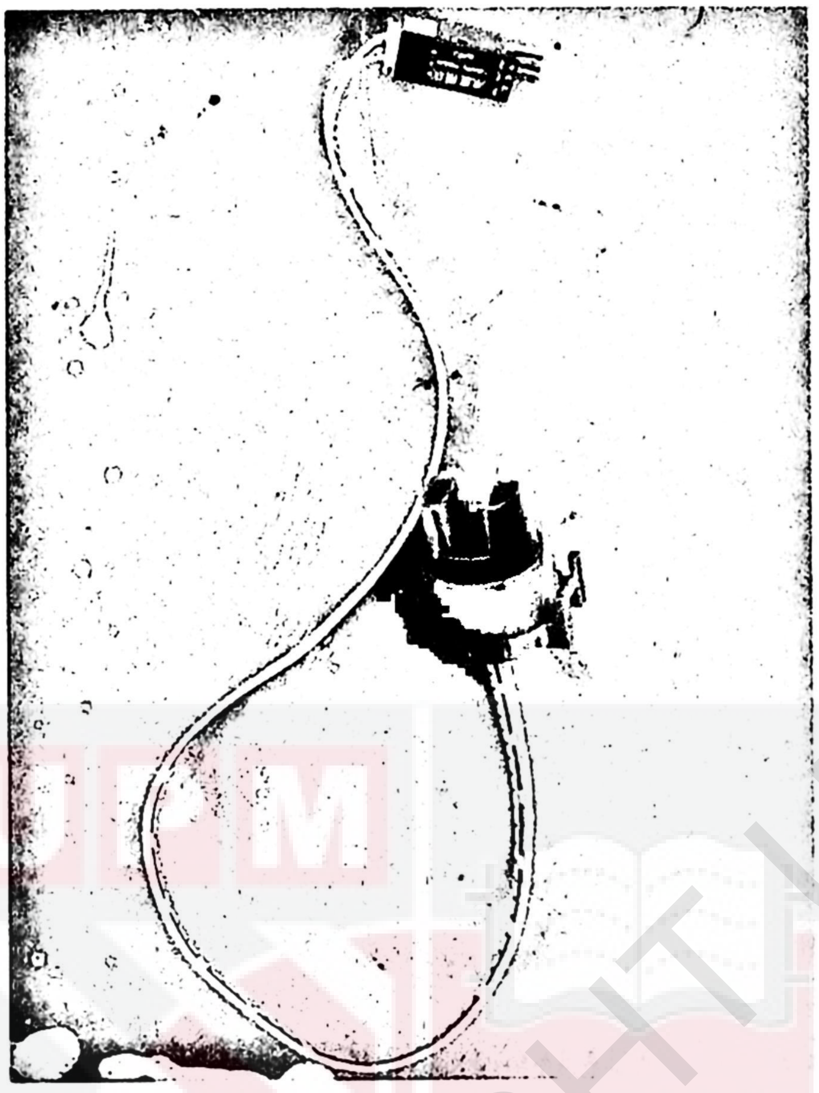

Figure 7: Turbidity and Humidity Sensor

3.4 PREPARATION OF MEASUREMENT DEVICES AND MATERIALS

Turbidity meter, Humidity meter, pH meter and Thermometer needed to measure the properties of nutrient solution. Fertilizer A & B is needed to provide the nutrient for the crops.

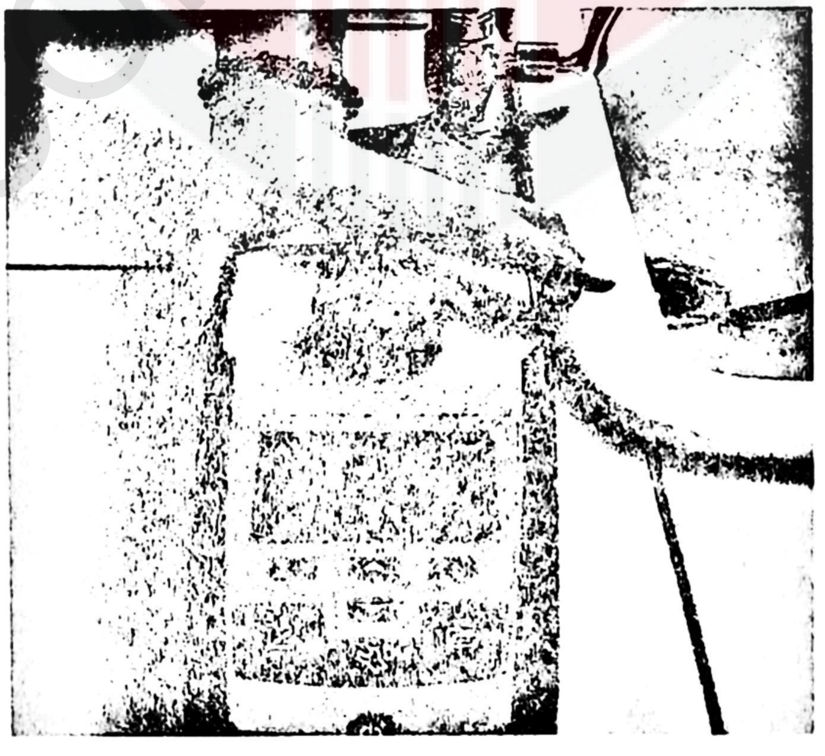

Figure 8: Turbidity and Humidity meter

Figure 9: pH meter and thermometer

3.5 CONNECTION BETWEEN IOT SYSTEM AND THE SMART PHONE

An App Named "Blynk" is needed to install into the smart phone and four icon of gauge is needed to display the reading. The smart phone have to link with IoT system by using WIFI signal. The coding the run the process is needed to develop in programming in order to transfer the data between them.

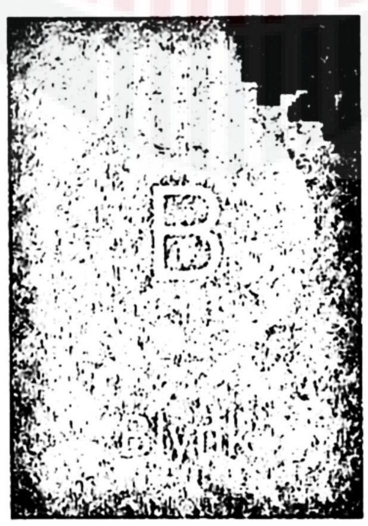

Figure 10: Smart Phone App Named Blynk

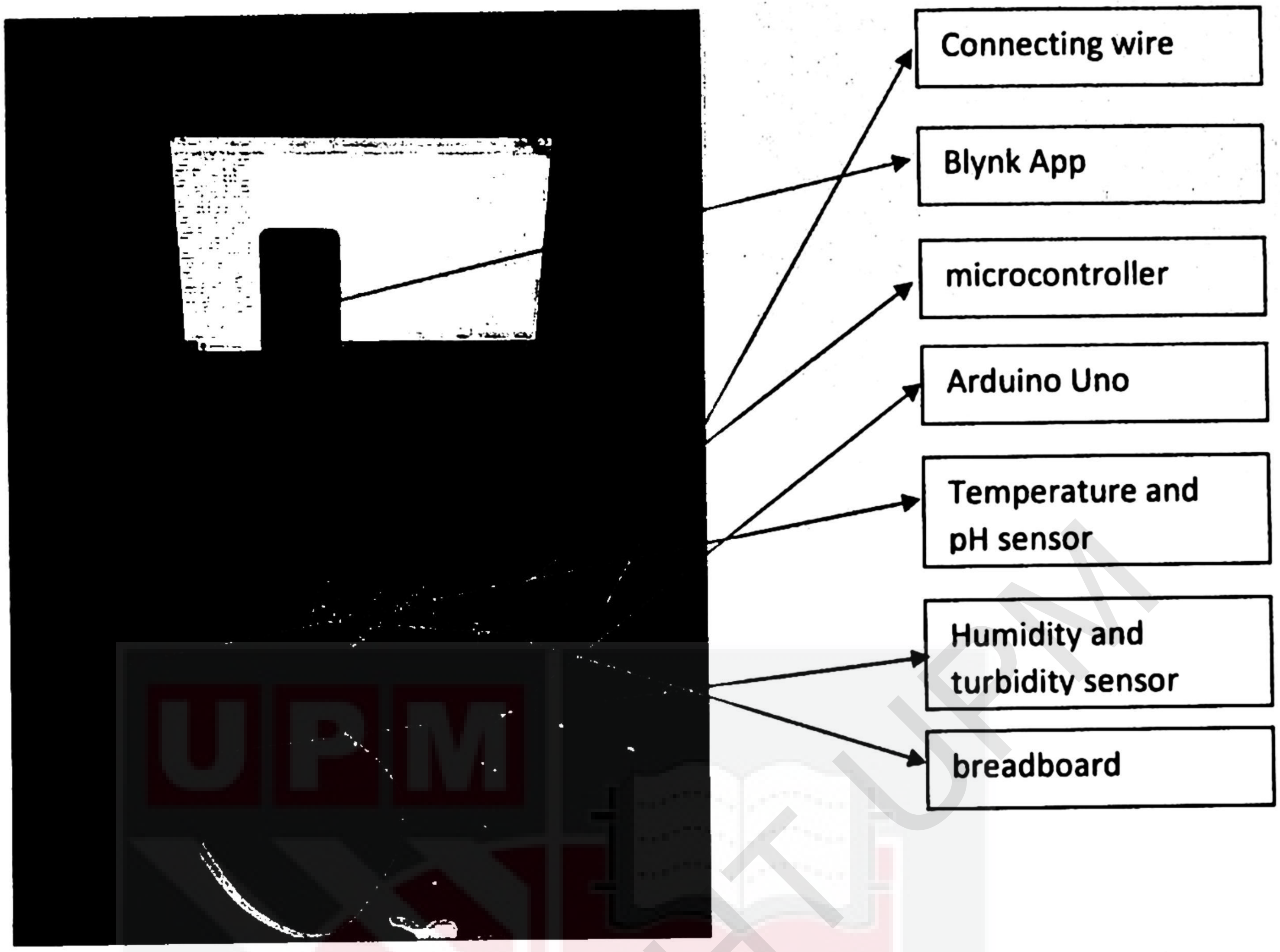

Figure 11: connection between IoT System and Phone

3.6 STUDY THE PARAMETER OF NUTRIENT SOLUTION

A complete set of IoT system with sensor and connected to a smart phone is installed in the along the piping system to test the quality of solution. A week time experiment is carried out in Macro Agriculture S/B farm to study the quality of nutrient solution using for irrigation system. Temperature, pH value, moisture, and turbidity of the solution are tested and recorded in the memory of phone.

3.7 VALIDATION THE DATA BETWEEN DEVICES AND IOT SYSTEM

The data stored in memory of smart phone is validate by compared to the reading measured by using measuring devices. The objective is valid when the comparison between the differences is less than 5%.

3.8 EXPECTED OUTCOME

Farmers recently face three major problems in vegetable agriculture sector which already mentioned above including the involvement of old technique in farming, high production cost and quality controlling. In this study, an IoT-based with sensor system is designed to overcome these problems faced. This study is carry out in a plant factory with vertical planting medium design which can produce more yield in a same size of space compared to traditional planting design. Three level planting medium design is to be used in this study as the result, three times yield produce compared to flat planting design.

The labor work is reduced with an IoT technology for hydroponic system in plant factory. Weed removing work is totally eliminated and little amount of labor needed to be used to monitoring and controlling the irrigation system for a large scale farming. The production cost is reduced when the amount of labor is reduced. Multiple of sensor such as temperature sensor, pH value sensor, moisture sensor, nutrient content sensor, and EC sensor is used to detect the characteristic of water. The reading will be recorded into the memory of smart phone so that farmers can provide the need of plant in the right amount and time. As the result, the quality of the plant is preserved.

CHAPTER 4

RESULT AND DISCUSSION

4.1 DEVELOPMENT OF IOT SYSTEM USING ARDUINO

An Iot system with four sensors is developed and the circuit diagram is shown in below. Four sensors are connected in the system such as temperature sensor, pH sensor, turbidity sensor and humidity sensor. All sensors are connected to a board with connecting wire. Two difference types of water is chosen to be tested the ability of sensors. At least three reading is tested to increase the accuracy of results. The coding for development the system is generated as shown in Figure 16 and the result is recorded in Table 1 below.

		1	2	3	Average
Sample A	Temperature (°C)	36.00	36.00	36.00	36.00
	pH value	3.90	3.89	3.89	3.89
	Turbidity (NTU)	1.09	1.22	1.22	1.18
	Humidity (g/m^3)	38.00	40.00	41.00	39.67
Sample B	Temperature (°C)	36.00	36.00	36.00	36.00
	pH value	4.41	4.39	4.33	4.38

	Turbidity (NTU)	1.25	1.27	1.33	1.28
	Humidity (g/m^3)	34.00	39.00	35.00	36.00

Table 1 :The data obtained by using IoT system

Figure 12: Sample A (Fresh Water)

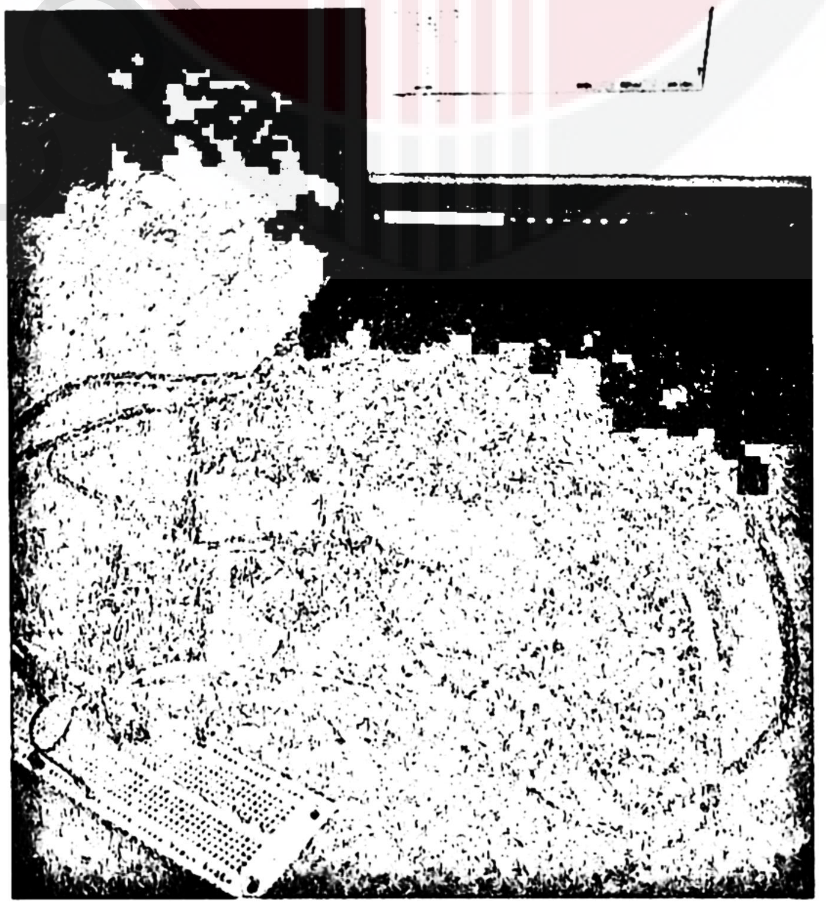

Figure 13: Testing for Sample A

Figure 14: Sample B (dirty Water)

Figure 15: Testing for Sample B

```
#include <SoftwareSerial.h>
#include <SimpleDHT.h>

SoftwareSerial tx(2, 3);

int pinDHT11 = 5;
SimpleDHT11 dht11(pinDHT11);

#define SensorPin A0            //pH meter Analog output to Arduino Analog Input 0
#define Offset 0.00             //deviation compensate
#define LED 13
#define samplingInterval 20
#define printInterval 800
#define ArrayLenth  40    //times of collection
int pHArray[ArrayLenth];   //Store the average value of the sensor feedback
int pHArrayIndex=0;

void setup(void){
  pinMode(LED,OUTPUT);
  tx.begin(9600);
  Serial.begin(9600);
  Serial.println("Arduino IoT Sensors Hub!\n");
}
```

```
    String data = "ph=" + String(pHValue) + ",tu=" + String(turbidity) + ",h=" + String(humidity) + ",t=" + String(temperature);

    Serial.println("Sensors: " + data);
    tx.println(data);
    digitalWrite(LED,digitalRead(LED)^1);
    printTime=millis();
  }
}

double avergearray(int* arr, int number){
  int i;
  int max,min;
  double avg;
  long amount=0;
  if(number<=0){
    Serial.println("Error number for the array to avraging!/n");
    return 0;
  }
  if(number<5){   //less than 5, calculated directly statistics
    for(i=0;i<number;i++){
      amount+=arr[i];
    }
```

```
    avg = amount/number;
    return avg;
  }else{
    if(arr[0]<arr[1]){
      min = arr[0];max=arr[1];
    }
    else{
      min=arr[1];max=arr[0];
    }
    for(i=2;i<number;i++){
      if(arr[i]<min){
        amount+=min;        //arr<min
        min=arr[i];
      }else {
        if(arr[i]>max){
          amount+=max;    //arr>max
          max=arr[i];
        }else{
          amount+=arr[i]; //min<=arr<=max
        }
      }//if
    }//for
    avg = (double)amount/(number-2);
  }//if
  return avg;
}
```

Figure 16: The coding Developed in System to Read the Data From the Sensors

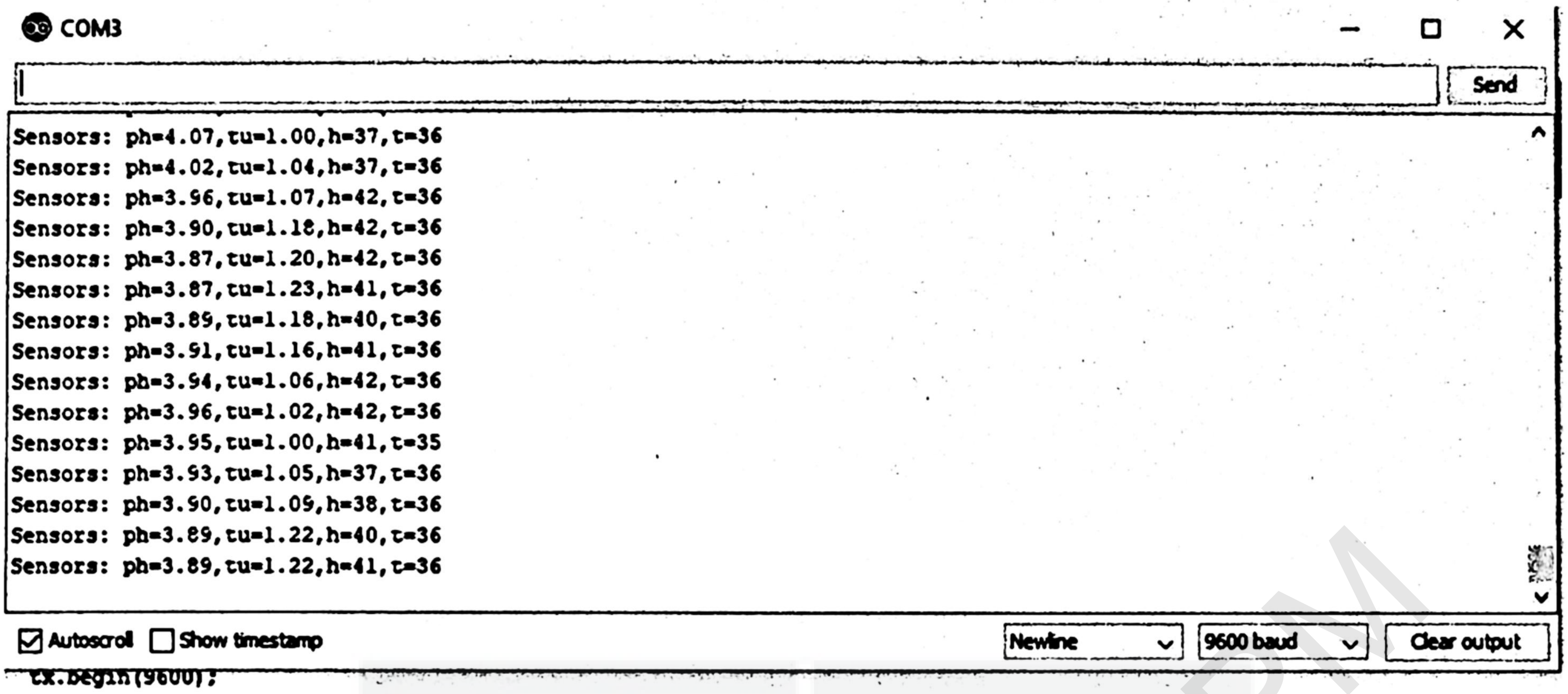

Figure 18: Result for Sample A

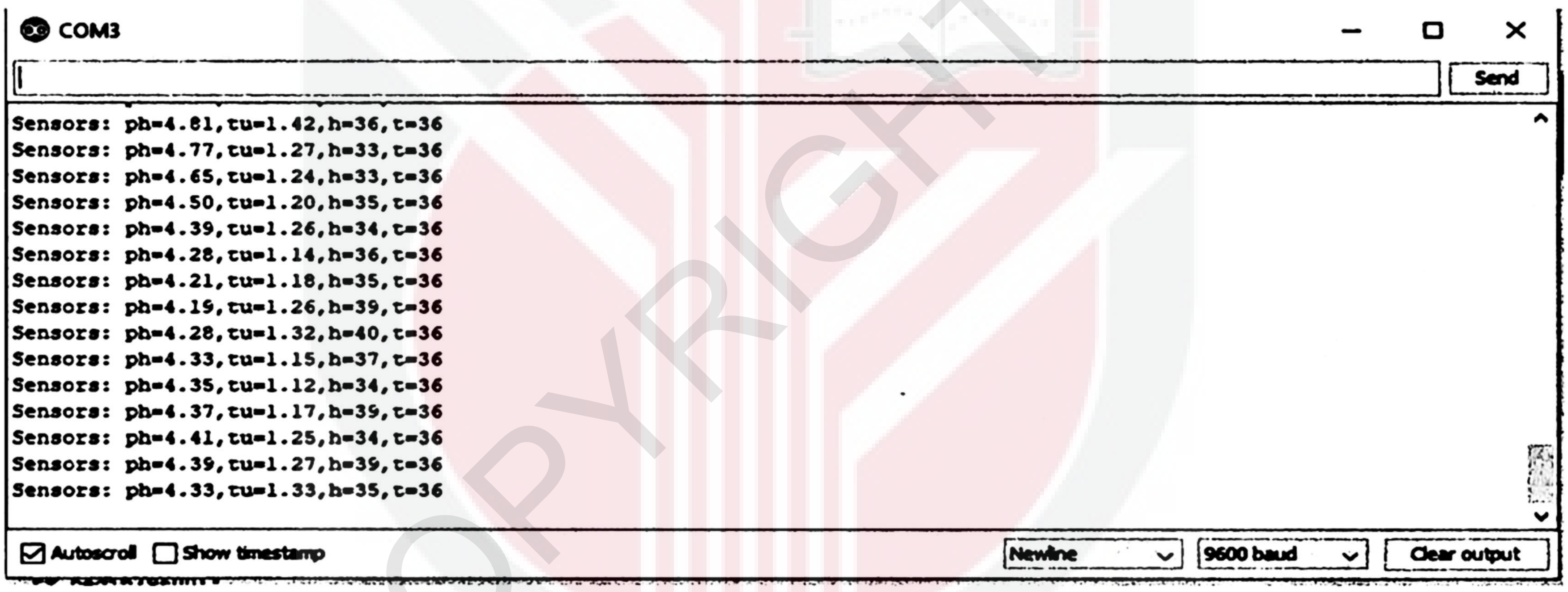

Figure 17: Result for Sample B

Discussion:

Table 1 above showed the different quality of water obtained by using IoT system. The temperature for both water sample is the same which is 36ºC but there is slight difference in pH value, humidity and turbidity. The sample A had a lower value of pH and turbidity but had a higher value of humidity compared to sample B. This experiment is testing the ability of IoT system in getting a consistent results.

4.2 CONNECTION BETWEEN IOT SYSTEM AND BLYNK

Blynk App is downloaded in smart phone and a name "FYP Adruino" is given as the title of the project. The App is connected to Iot system by using Wifi. Four gadgets with analog display are shown on the monitor of the phone. The coding is generated and shown in picture 19. The connection between Iot and Blynk App is shown in Figure 21 below.

WeMos_Blynk | Arduino 1.8.8

File Edit Sketch Tools Help

WeMos_Blynk

```
#define BLYNK_PRINT Serial

#include <ESP8266WiFi>
#include <BlynkSimpleEsp8266.h>
#include <SoftwareSerial.h>

SoftwareSerial tx(D4, D3);

char auth[] = "7bb39c612ee64191816a5bd576463801";

char ssid[] = "khoyphone";
char pass[] = "0until90";

void setup(){
  Serial.begin(9600);
  tx.begin(9600);
  Blynk.begin(auth, ssid, pass);
}

void loop(){
  Blynk.run();

  if(tx.available()){
    String data = tx.readStringUntil('\n');
    // ph=11.25,tu=4.99,h=35,t=31
    String pH = data.substring(data.indexOf("ph=") + 3, data.indexOf(",tu="));
    String turbidity = data.substring(data.indexOf(",tu=") + 4, data.indexOf(",h="));
    String humidity = data.substring(data.indexOf(",h=") + 3, data.indexOf(",t="));
    String temperature = data.substring(data.indexOf(",t=") + 3);

    Serial.println("pH Value: " + pH);
    Serial.println("Turbidity Value: " + turbidity);
    Serial.println("Humidity Value: " + humidity);
    Serial.println("Temperature Value: " + temperature);

    Blynk.virtualWrite(V0, pH);
    Blynk.virtualWrite(V1, turbidity);
    Blynk.virtualWrite(V2, humidity);
    Blynk.virtualWrite(V3, temperature);
  }
}
```

Figure 19: The coding to link IoT system With Blynk

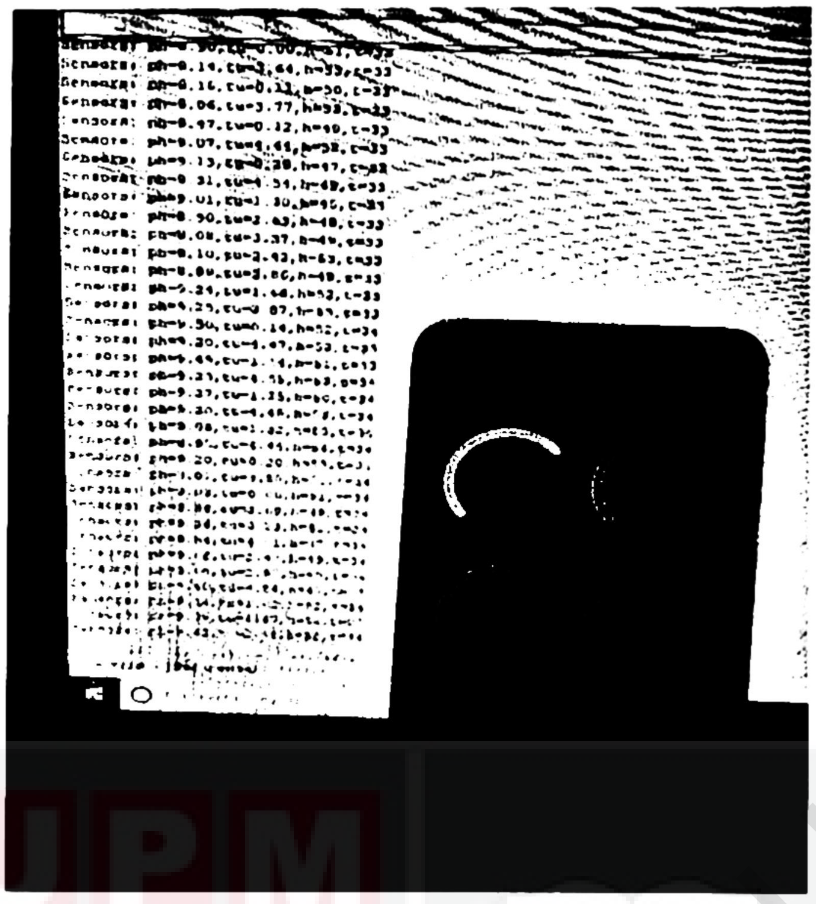

Figure 20: The data displayed on Computer and Phone

Figure 21:The connection between IoT System and Blynk

Discussion:

Figure 20 showed that the reading on the screen on computer is the same with the data displayed on the phone. The connection between them is well and the coding inserted is right. Thus, a complete IoT system in ready to be used to study the parameter of nutrient solution using in Plant Factory. But there is so problem happened due to the connection of WIFI. Sometimes the System is not able to connect with phone because the poor signal of WIFI. The strength of WIFI have to be concerned during the experiment.

4.3 DETERMINE THE BASIC PARAMETER OF NUTRIENT SOLUTION USED IN HYDROPONIC SYSTEM

An experiment is carried out to test the parameter of nutrient solution used for hydroponics system in a company named Macro Agriculture Sdn Bhd located at Cameron Highlands. The green lettuce is the main agriculture products produces by this company. The quality of the fertilizers used for irrigation is always the most important part for high quality products. A study on the basic characteristic of nutrient solution is carried by Iot system to determine the optimum requirement for hydroponic crop products. A week time of continuous testing is needed to obtain a high accuracy result. The result is tabulated in table 9 below.

Day 1

Date: 11/05/2019

Time: 10.00 a.m.

Condition of weather: Sunny day

Surrounding Temperature: 24°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity,g/m^3
Sample	1	23.00	6.34	0.89	39.00

	2	23.00	6.76	0.95	43.00
	3	23.00	6.50	1.06	40.00
	Average	23.00	6.53	0.97	40.67

Table 2: The Temperature, pH, Turbidity and Humidity in 1st day

Day 2

Date: 12/05/2019

Time: 10.00 a.m.

Condition of weather: Sunny day

Surrounding Temperature: 23°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m^3
Sample	1	23.00	6.80	1.02	36.00
	2	23.50	6.54	0.85	44.00
	3	23.00	6.46	1.01	38.00
	Average	23.17	6.60	0.96	39.33

Table 3: The Temperature, pH, Turbidity and Humidity in 2nd day

Day 3

Date: 13/05/2019

Time: 10.00 a.m.

Condition of weather: Raining day

Surrounding Temperature: 19°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m³
Sample	1	24.00	6.80	1.05	38.00
	2	23.50	6.64	0.95	40.00
	3	24.00	6.87	0.91	39.00
	Average	23.83	6.77	0.97	39.00

Table 4: The Temperature, pH, Turbidity and Humidity in 3rd day

Day 4

Date: 14/05/2019

Time: 10.00 a.m.

Condition of weather: Raining heavily

Surrounding Temperature: 18°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m³
Sample	1	24.50	6.84	1.02	39.00
	2	24.50	6.68	0.92	42.00
	3	24.00	6.92	0.94	37.00
	Average	24.33	6.81	0.96	39.33

Table 5:The Temperature, pH, Turbidity and Humidity in 4th day

Day 5

Date: 15/05/2019

Time: 10.00 a.m.

Condition of weather: Cloudy day

Surrounding Temperature: 21°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m³
Sample	1	23.50	6.75	0.99	37.00
	2	23.50	6.60	1.02	41.00
	3	23.00	6.85	0.98	40.00
	Average	23.33	6.73	0.99	39.33

Table 6: The Temperature, pH, Turbidity and Humidity in 5th day

Day 6

Date: 16/05/2019

Time: 10.00 a.m.

Condition of weather: Slightly Raining

Surrounding Temperature: 20°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m³
Sample	1	23.50	6.77	1.09	42.00
	2	23.00	6.87	1.01	40.00
	3	23.00	6.63	0.91	37.00
	Average	23.16	6.76	1.00	39.67

Table 7: The Temperature, pH, Turbidity and Humidity in 6th day

Day 7

Date: 17/05/2019

Time: 10.00 a.m.

Condition of weather: Sunny day

Surrounding Temperature: 24°C

Parameter of water		Temperature,°C	pH	Turbidity,NTU	Humidity, g/m^3
Sample	1	23.00	6.31	0.87	41.00
	2	23.00	6.70	1.05	38.00
	3	23.00	6.56	1.00	40.00
	Average	23.00	6.52	0.97	39.67

Table 8: The Temperature, pH, Turbidity and Humidity in 7th day

Parameter	Temperature	pH Value	Turbidity	Humidity
Day 1	23.00	6.53	0.97	40.67
Day 2	23.17	6.60	0.96	39.33
Day 3	23.38	6.77	0.97	39.00
Day 4	24.33	6.81	0.96	39.33
Day 5	23.33	6.73	0.99	39.33
Day 6	23.16	6.76	1.00	39.67
Day 7	23.00	6.52	0.97	39.67
Average	23.34	6.67	0.97	39.67

Table 9: The average value of nutrient solution used

Discussion:

From the table above showed that the reading of nutrient solution used for three type of weather which is raining day, cloudy day and sunny day. The results showed that the reading of temperature and pH is slight high in cloudy and raining day. This is because when the surrounding temperature is decreasing, the temperature of used nutrient is getting increase so that the crop experience a constant temperature all the time regardless the changes of weather. The reading of turbidity and humidity is remain the same all the time. In this experiment, the parameter of nutrient solution which is suitable for hydroponic farming is 23.34°C, 6.67 of pH value, 0.97 of turbidity value and 39.67 of humidity value.

4.4 VALIDATION OF DATA COLLECTED IN SMART PHONE WITH THE DATA MEASURED BY DEVICES

Three samples with different characteristic are used to be testing the ability of the Iot based system with sensors and the commercial devices. The results are tabulated in the table 10 and the differences between the data collected is tabulated in the figure 22,23, and 24 below.

		IoT	Device	IoT	Device	IoT	Device	IoT	Device
Parameter		Temperature,°C		pH value		Turbidity,NTU		Humidity, g/m^3	
Sample 1	1	59.00	59.00	7.15	7.20	1.56	1.55	36.00	39.00
	2	59.00	58.00	7.20	7.25	1.41	1.65	41.00	35.00
	3	59.00	59.00	7.18	7.22	1.52	1.51	40.00	38.00
	Average	59.00	58.67	7.18	7.22	1.50	1.57	39.00	37.33
Sample 2	1	26.00	26.00	5.19	5.21	1.32	1.36	42.00	36.00
	2	25.00	25.00	5.11	5.25	1.33	1.40	36.00	37.00
	3	26.00	26.00	5.29	5.28	1.35	1.39	38.00	38.00
	Average	25.67	25.67	5.19	5.25	1.33	1.38	38.67	37.00
Sample 3	1	26.00	25.00	3.22	3.20	0.99	1.06	42.00	40.00
	2	26.00	25.00	3.18	3.22	1.01	0.96	39.00	39.00
	3	25.00	26.00	3.11	3.25	0.90	0.98	40.00	44.00
	Average	25.67	25.33	3.17	3.22	0.97	1.00	40.33	41.00

Table 10: The Data collected from IoT System and Devices

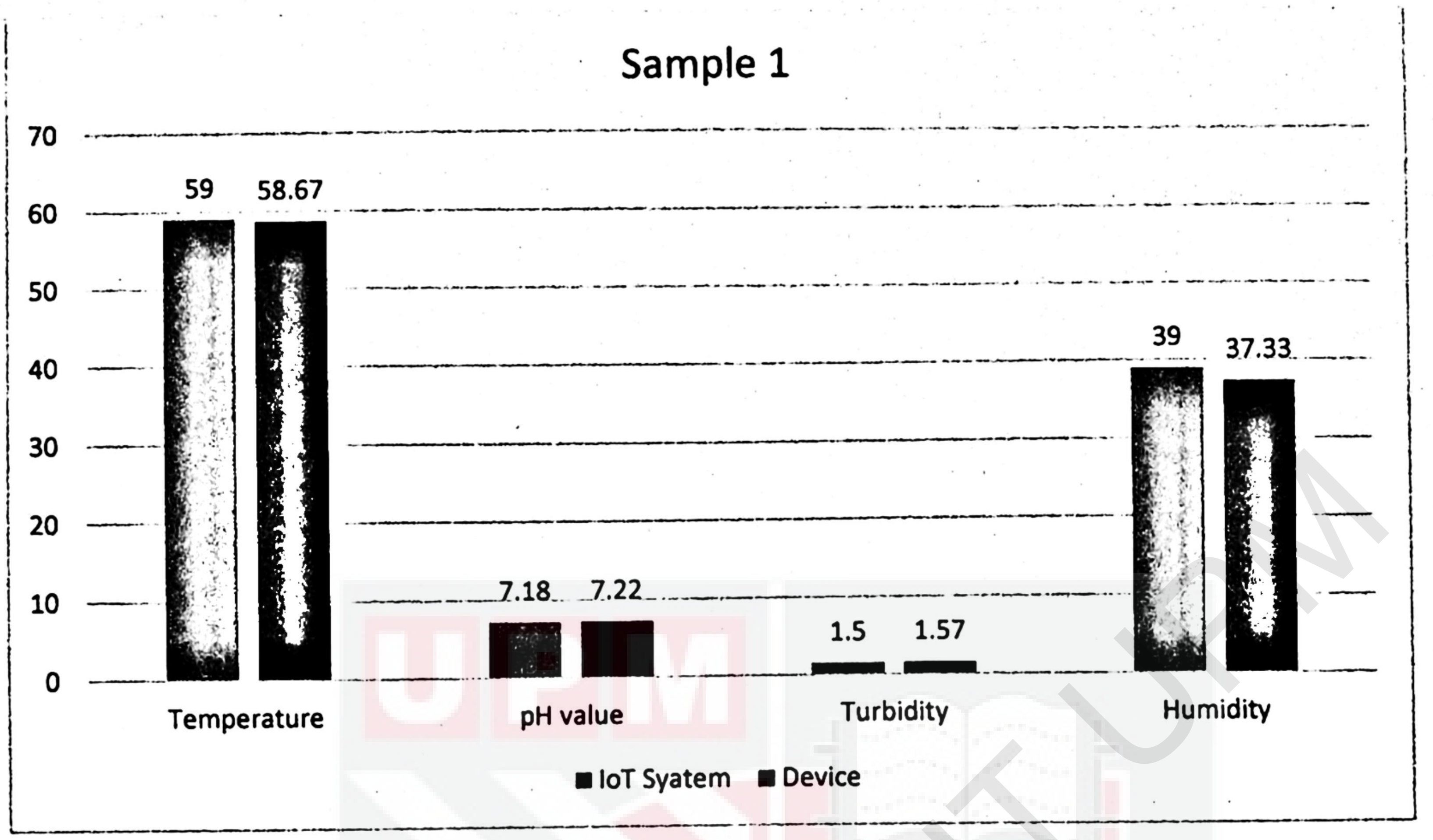

Figure 22: Comparison between the IoT System and Devices (Sample 1)

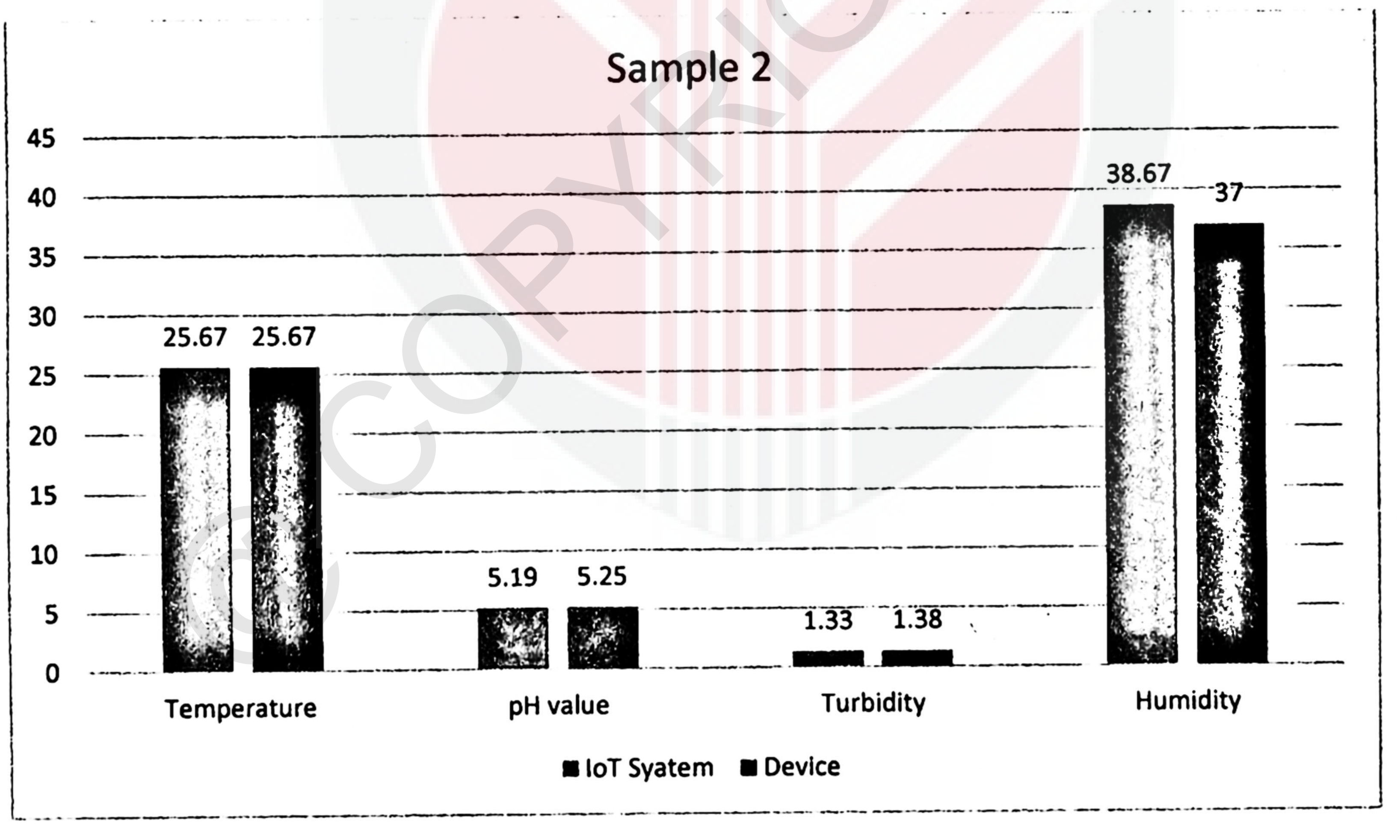

Figure 23: Comparison between IoT System and Devices (Sample 2)

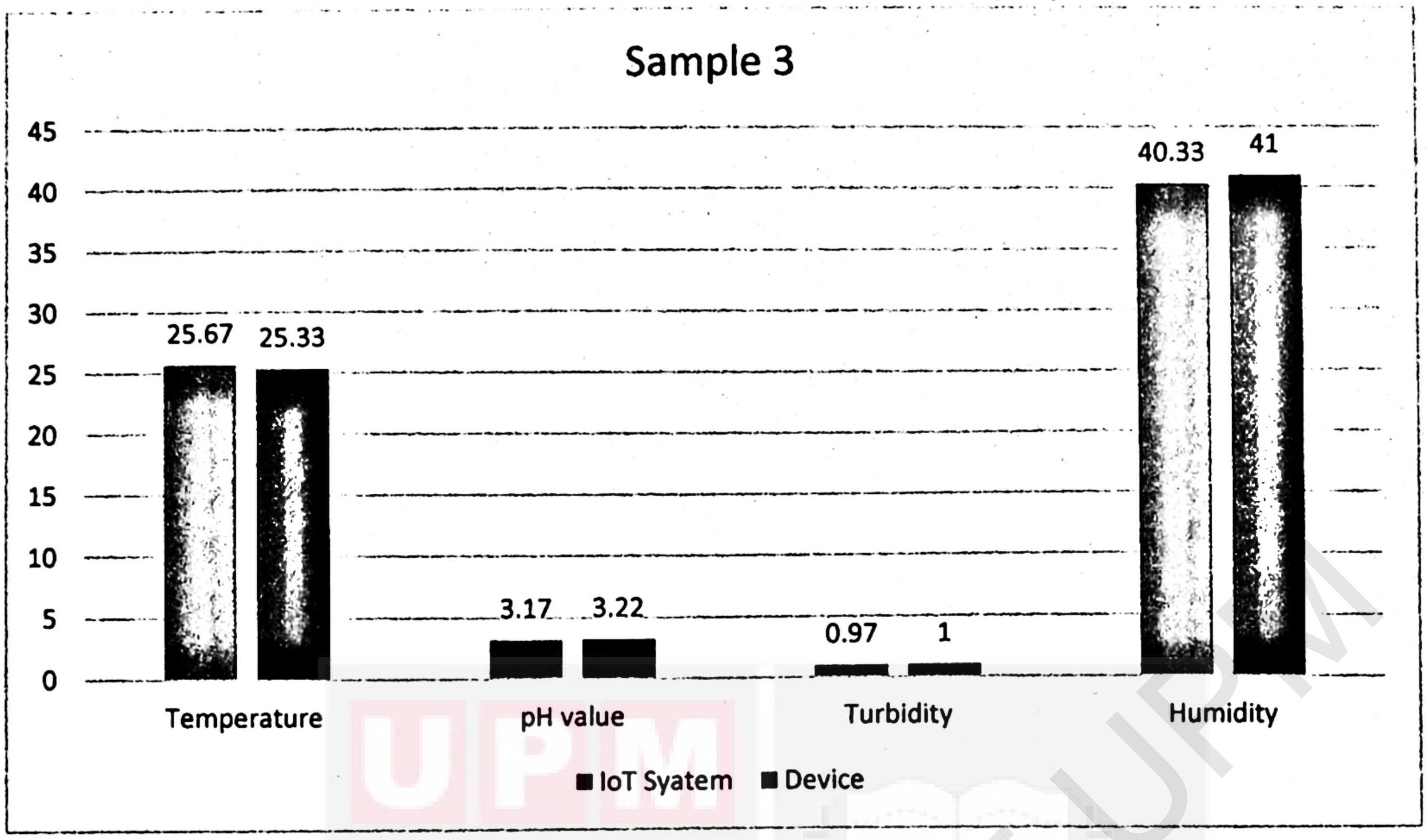

Figure 24: Comparison between IoT System and Devices (Sample 3)

$$Differences_{parameter} = \frac{IoT_{parameter} - Device_{parameter}}{IoT_{parameter}} \times 100\%$$

$Sample\ 1_{Tem} = \frac{59.00-58.67}{59.00} \times 100\% = 0.56\ \%$
$Sample\ 1_{pH} = \frac{7.18-7.22}{7.18} \times 100\% = 0.56\ \%$
$Sample\ 1_{Tur} = \frac{1.50-1.57}{1.50} \times 100\% = 4.67\ \%$
$Sample\ 1_{Hum} = \frac{39.00-37.33}{39.00} \times 100\% = 4.28\ \%$
$Sample\ 2_{Tem} = \frac{25.67-25.67}{25.67} \times 100\% = 0.00\ \%$
$Sample\ 2_{pH} = \frac{5.19-5.25}{5.19} \times 100\% = 1.16\ \%$
$Sample\ 2_{Tur} = \frac{1.33-1.38}{1.33} \times 100\% = 3.76\ \%$
$Sample\ 2_{Hum} = \frac{38.67-37.00}{38.67} \times 100\% = 4.32\ \%$
$Sample\ 3_{Tem} = \frac{25.67-25.33}{25.67} \times 100\% = 1.28\ \%$
$Sample\ 3_{pH} = \frac{3.17-3.22}{3.17} \times 100\% = 1.58\ \%$

$Sample\ 3_{Tur} = \frac{0.97-1.00}{0.97} \times 100\% = 3.09\ \%$
$Sample\ 3_{Hum} = \frac{40.33-41.00}{40.33} \times 100\% = 1.66\ \%$

Table 11: The Differences Between Both Data in %

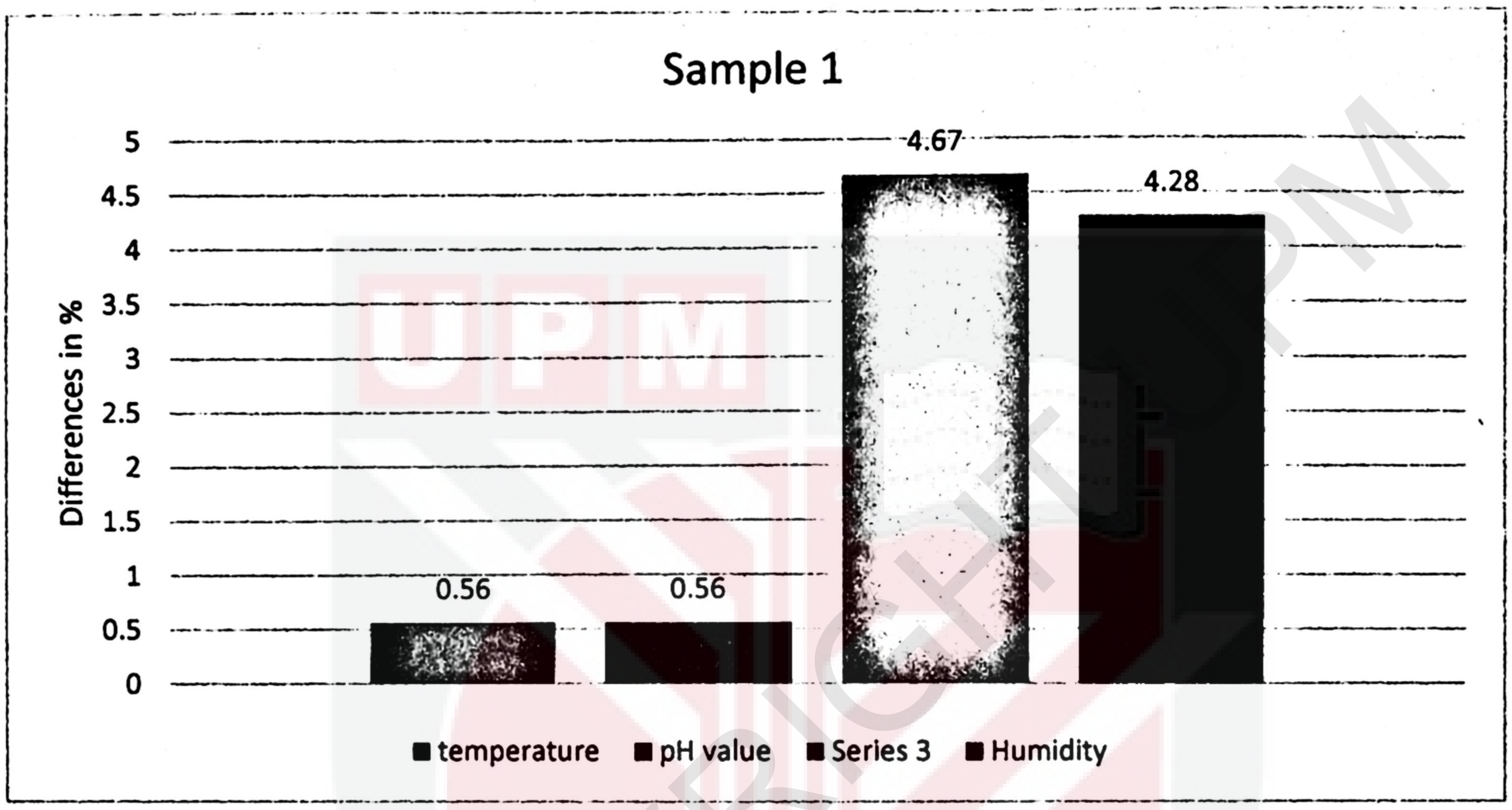

Figure 25: The Differences in % for Sample 1

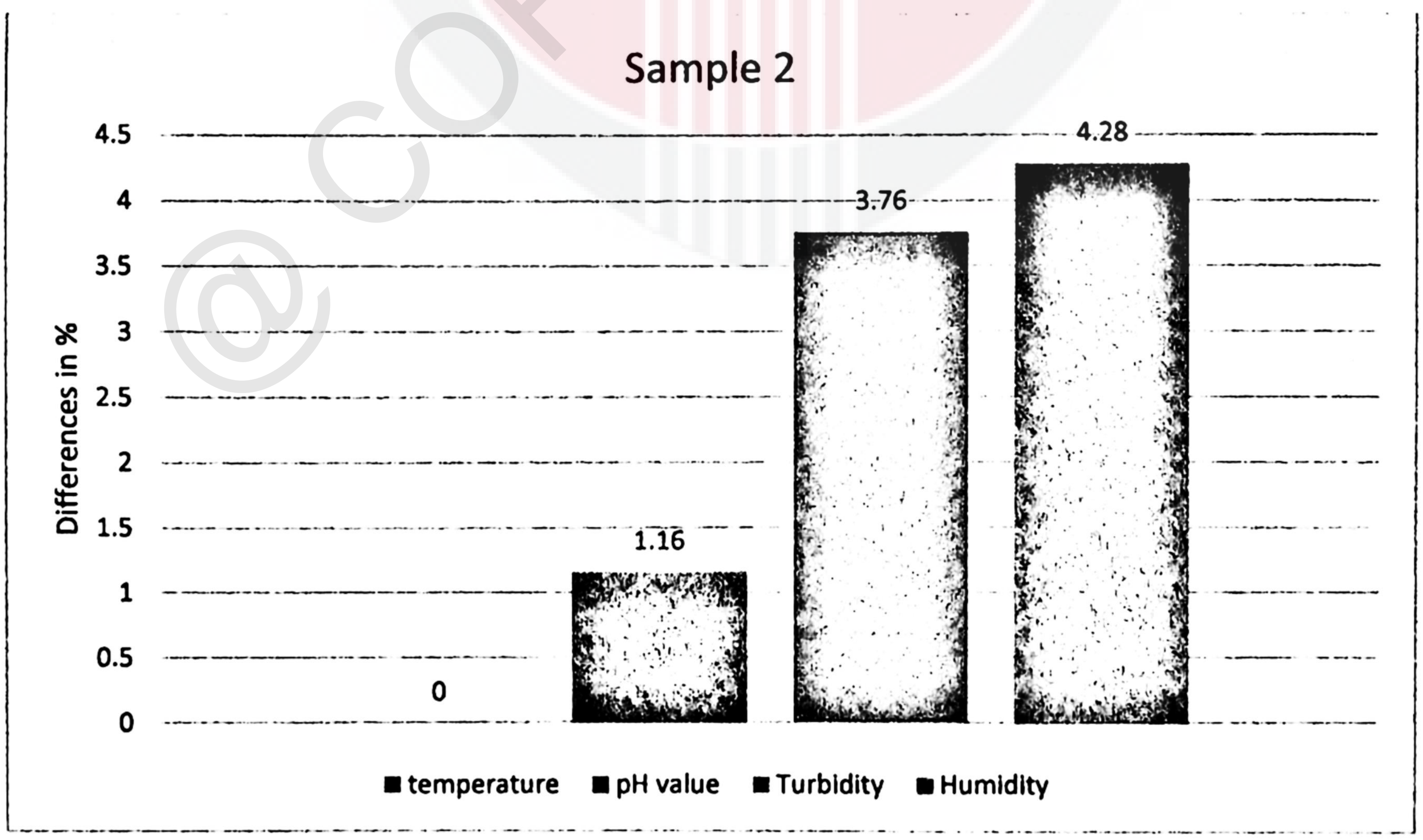

Figure 26: The Differences in % for Sample

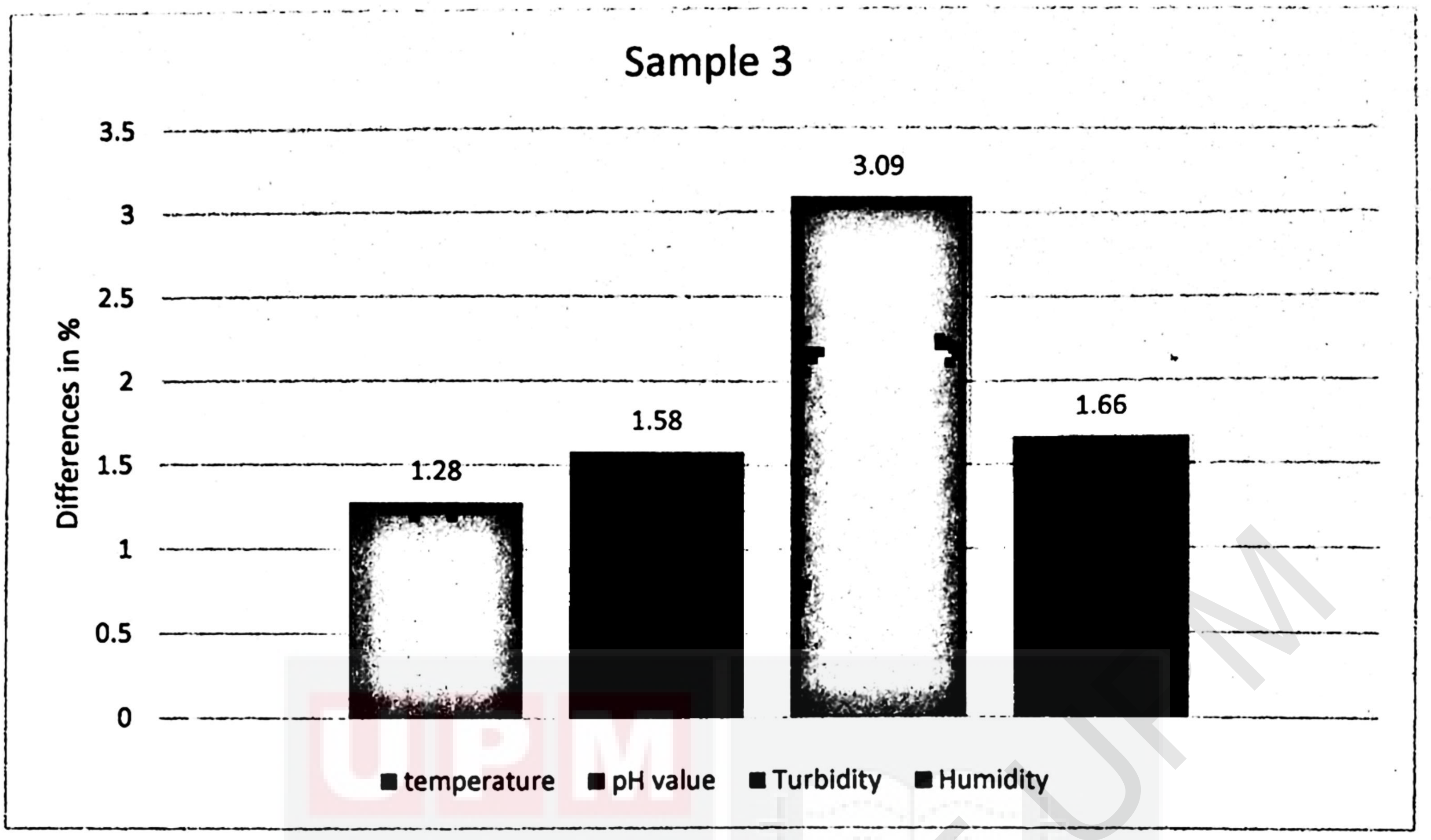

Figure 27: The Differences in % for Sample 3

Discussion:

The table and graphs above showed that the differences of temperature and pH for three sample is very less which is below 1.6 % and the differences between turbidity and humidity is slightly more but below 4.8 %. Thus, the results can be concluded valid because the differences of data collected with IoT System and existing devices is less than 5 % for three sample. The completed IoT system is ready for the use of agriculture sector in Malaysia.

CHAPTER 5

CONCLUSION

5.1 SUMMARY

An Iot system with several sensors that connected to smart phone is successfully developed. Data measured from sensors can be directly recorded into a smart phone. The data is displayed on the screen enables users to know the quality of the water easily. Instant respond can be carried out to improve the quality of the water.

Besides that, basic parameter of nutrient solution used for hydroponic system are detected by using Iot system. Low temperature and neutral value of water is suitable for crop irrigation.

There are slightly difference between the data collected in smart phone and the data measured from devices. It happened may cause by instrumental error and environmental error.

5.2 RECOMMENDATION

This Iot system is the basic ideal for monitoring and controlling system in plant factory. It only consists of limited function and there still a lot of part can be improve. Due to the limitation of time and knowledge, other advance functions such as Relay Function and Automated Respond cannot be achieve in this project. Therefore, extra time and assistance from other professional is needed for further development.

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APPENDICES

Week / activity	1	2	3	4	5	6	7	8	9	[redacted]				14
Introduction	/	/												
Literature Review		/	/											
Methodology			/	/										
Expected Outcome				/	/									
Reference					/	/								
Proposal Submission							/							
Proposal Improvement								/	/	/	/	/	/	
FYP Presentation										/				
FYP Progress Report Submission														/

Appendice 1: The Gantt Chart For 1st Sem

Week / activity	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Submission on Turnitin	/	/												
FYP Progress Report 2 Submission		/	/	/	/	/	/	/						
Formatting Thesis									/	/	/	/	/	/
FYP Exibition														/
Thesis Submission														/

Appendice 2: The Gantt Chart For 2nd Sem