
# DEVELOPMENT OF A WATER QUALITY MONITORING SYSTEM USING IOT FOR AGRICULTURAL INDUSTRIES (NEAR NIPA PALM)

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# DEVELOPMENT OF A WATER QUALITY MONITORING SYSTEM USING IOT FOR AGRICULTURAL INDUSTRIES (NEAR NIPA PALM)

HU GUO HUAN

A dissertation submitted in partial fulfilment
of the requirement for the degree of
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To my beloved family and friends

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# ABSTRACT

Water plays a vital role in the growth and development of agricultural crops, including the Nipa palm. This research will focus on the Nipa palm (Nypa fruticans) that survives in the mangrove forest. Since nipa palm is constantly inundated, monitoring water properties is needed to detect the levels of heavy metals, major metals, trace elements and nutrients in the water. However, most of the current IoT monitoring systems for agriculture does not equip with reliable water quality sensors for water quality monitoring. Besides, sufficient nutrient availability and salinity is a factor that enables the nipa palm to maintain continuous growth and a healthy population. Therefore, this project will develop a reliable water quality monitoring system for obtaining data on water parameters near nipa palm. This water quality monitoring system will equip with five sensors, including pH, electrical conductivity, turbidity, temperature, and DHT-11 sensor. All the sensor data collected will be displayed on OLED and uploaded to the IoT platform, ThingSpeak, for further analysis. Nipa palm fruit will be gathered from each site, and the relationship between the physicochemical parameters of the water and the size of the nipa palm fruit will be assessed. The analysis reveals that electrical conductivity and salinity are key factors influencing the size of the nipa palm fruit. If the electrical conductivity and salinity values exceed 20mS/cm, the nipa palm fruit produced will likely be smaller. Other water parameters such as pH, water temperature, and turbidity also play significant roles in achieving a good population and larger-sized nipa palm fruit. By developing a robust monitoring system, farmers and agricultural practitioners can make informed decisions on water use and management strategies for Nipa palm plantations.

# ABSTRAK

Air memainkan peranan penting dalam pertumbuhan dan perkembangan tanaman pertanian, termasuk pokok Nipah. Penyelidikan ini akan memberi tumpuan kepada pokok Nipah (Nypa fruticans) yang hidup di hutan bakau. Memandangkan pokok nipah sentiasa ditenggelami air, pemantauan sifat air diperlukan untuk mengesan tahap logam berat, logam utama, unsur surih dan nutrien di dalam air. Walau bagaimanapun, kebanyakan sistem pemantauan IoT semasa untuk pertanian tidak dilengkapi dengan penderia kualiti air yang boleh dipercayai untuk pemantauan kualiti air. Selain itu, ketersediaan nutrien dan kemasinan yang mencukupi merupakan faktor yang membolehkan pokok nipah mengekalkan pertumbuhan berterusan dan populasi yang sihat. Oleh itu, projek ini akan membangunkan sistem pemantauan kualiti air yang lebih sesuai untuk mendapatkan data parameter air berhampiran pokok nipah. Sistem pemantauan kualiti air ini akan dilengkapi dengan lima sensor, termasuk pH, kekonduksian elektrik, kekeruhan, suhu dan sensor DHT-11. Semua data sensor yang dikumpul akan dipaparkan pada OLED dan dimuat naik ke platform IoT, ThingSpeak, untuk analisis lanjut. Buah nipah akan dikumpul dari setiap tapak, dan hubungan antara parameter fizikokimia air dan saiz buah nipah akan dinilai. Analisis mendedahkan bahawa kekonduksian elektrik dan kemasinan adalah faktor utama yang mempengaruhi saiz buah nipah. Jika kekonduksian elektrik dan nilai kemasinan melebihi 20mS/cm, buah nipah yang dihasilkan berkemungkinan lebih kecil. Parameter air lain seperti pH, suhu air, dan kekeruhan juga memainkan peranan penting dalam mencapai populasi yang baik dan buah nipah bersaiz lebih besar. Dengan membangunkan sistem pemantauan yang mantap, petani dan pengamal pertanian boleh membuat keputusan termaklum mengenai penggunaan air dan strategi pengurusan untuk ladang pokok Nipah.

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| | |
|---|---|
| AC | Alternating current |
| ADC | Analog-to-digital converter |
| ANOVA | Analysis of variance |
| AT | ATtention |
| Bit | Binary digit |
| BNC | Bayonet Neill–Concelman |
| DC | Direct current |
| DMA | Direct memory access |
| DO | Dissolved Oxygen |
| EC | Electrical Conductivity |
| EEPROM | Electrically Erasable Programmable Read-Only Memory |
| F.S | Full Scale |
| GND | Ground |
| GPIO | General-purpose input/output |
| GSM | Global System for Mobile Communications |
| HTTP | Hypertext Transfer Protocol |
| ICSP | In-circuit serial programming |
| IDE | Integrated Development Environment |
| IoT | Internet of Things |
| I2C | Inter-Integrated Circuit |
| KB | Kilobytes |
| LCD | Liquid-crystal display |
| LED | Light-emitting diode |

| | |
|---|---|
| OLED | Organic Light-Emitting Diode |
| MATLAB | Matrix Laboratory |
| PCB | Printed Circuit Board |
| pH | Potential of Hydrogen |
| PWM | Pulse width modulation |
| RAM | Random-access memory |
| RH | Relative Humidity |
| ROM | Read-only memory |
| SCL | Serial Clock |
| SDA | Serial Data Line |
| SMS | Short Message Service |
| SPI | Serial Peripheral Interface |
| SWQM | Smart Water Quality Monitoring |
| TDS | Total Dissolved Solid |
| USB | Universal Serial Bus |
| WHO | World Health Organization |
| Wi-Fi | Wireless Fidelity |
| WQI | Water Quality Index |
| WQM | Water Quality Monitoring |
| WSN | Wireless Sensor Network |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

For the continued existence of humankind, water is an indispensable component. Typically, primary industries, such as farming and forestry, as well as secondary sectors, such as construction, industrial, and commercial, are the ones that make use of water. It serves as the central nervous system for many habitats, including lakes, rivers, streams, and wetlands. Nowadays, the water pollution problem rises a big challenge for the environment. Typically, water pollution happens when a variety of harmful chemicals or microorganisms are introduced into a body of water, resulting in water that is unsafe for human consumption or the environment [1].

As of today, the majority of this contamination is the result of diverse human activities. Human-made activities such as intensive agriculture, urbanization, deforestation, and industrialization have increased the contamination of water bodies. Besides human activities, natural calamities such as hurricanes, and earthquakes can also contribute to water contamination. In the case of drinking water, water-borne pathogens, such as bacteria from human and animal faeces, are the major cause of a host of infections [1]. Polluted water is hazardous to the environment because it washes critical nutrients from the soil and leaves massive levels of aluminium, which can harm plants.

Agriculture is a simplification of nature's food webs, a redirection of the energy grown by humans and consumed by animals [2]. It is one of the most significant accomplishments in human history, and it remains an indispensable and vital sector until today. Due to the expanding global population, the need for food is constantly rising. In order to guarantee that sufficient food is produced to sustain the world's population, food's health and growth rate are crucial. Water is crucial for sustaining food's health and growth rate, just like humans need water to survive and plants require water to flourish. Thus, this makes agriculture a sector that uses the most water in the world. Approximately 70%

of the world's water is used in agriculture each year [3]. Lack of water or use of contaminated water in crop production, harvesting and processing can lead to poor crop growth, severe disease, unsustainability and even death.

Mangroves are coastal intertidal wetland forests composed of halophytic tree and shrub species [4]. It only can grow at tropical and subtropical latitudes near the equator because it cannot withstand freezing temperatures [5]. Thus, makes mangroves fringe the world's subtropical and tropical coastlines, reaching as far north as Florida (~29°N) and southern Japan (~31°N) and as far south as the south coast of Australia (~38°S) [4]. Malaysia is one of the countries with mangrove forests and the third-largest mangrove-holding country in the world. Malaysia also boasts the highest diversity of mangrove plant species worldwide, having 48 out of the 69 global mangrove-only species [6]. In Malaysia, mangrove forests are usually found on the marine alluvium along the sheltered coast and estuaries in Peninsular Malaysia, Sabah, and Sarawak.

Considered one of the oldest living palms, the nipa palm (Nypa fruticans Wurmb.) is the only species able to adapt to the mangrove forest. This palm does not have a trunk and represents a dominant species in wetlands that are frequently flooded by brackish water. Local farmers cultivate the mangrove palm to make a variety of products in accordance with local cultures and ways of life. These products include syrups, thatching, desserts, and others [7].

The term "water quality" refers to the state of the water, including its chemical and physical properties (together referred to as "physicochemical parameters"), typically concerning how well it serves a particular function, such as being suitable for irrigation [8]. The water quality of a water body can be determined by several water parameters, including pH, conductivity, turbidity, temperature, dissolved oxygen, and others.

As brackish water is the water property that thrives nipa palm to grow sustainably, the physicochemical properties of water for the nipa palm need to be monitored in order to maintain the nipa palm's sustained development and productivity. Because at a particular concentration, any toxic substances in water can harm Nipa palm. Thus, monitoring of water properties is needed since this species is constantly inundated. Besides, the water's physicochemical properties would affect the fruits' size. Thus, it is necessary to develop a system that can check the water quality of nipa palm and act as an indicator to search for a new area for nipa production.

## 1.2 Problem Statement

In agriculture, most of the current IoT monitoring system does not equip with reliable water quality sensors for water quality monitoring. The water quality sensors in the current IoT monitoring system for agriculture involve pH, turbidity, and temperature sensors only. This is not enough to reflect the water quality that needs for the plant to grow well.

In order to maintain the sustained growth and healthy population of nipa palm, water with sufficient nutrients and salinity is required. The results of recent research [9] indicated that nipa palms would thrive in brackish water. So, excess freshwater or seawater in water for nipa palm growing can have an impact on growth and production. Besides that, agricultural activities and urban expansion have also significantly increased the naturally occurring amounts of heavy metals in brackish water, which has had an adverse effect on the growth of the frequently inundated nipa palm.

Based on the mentioned problem, a water quality monitoring system with IoT and reliable function will be designed and developed to monitor the water quality for agriculture industries and the environment near nipa palm. The microprocessor utilised in this system is an Arduino Uno, together with a customised Internet of Things (IoT) module, to make sure that sensor data from the Arduino board can be accessed or viewed on mobile phones using Wi-Fi.

## 1.3 Objectives

The purpose of the project is:

i. To investigate water quality system.

ii. To develop a reliable water quality monitoring system for obtaining data on water parameters near nipa palm.

iii. To analyse physicochemical parameters in water for nipa palm.

## 1.4 Scope of project

To develop a water quality monitoring system that can monitor the physicochemical water parameter for the nipa palm and analyse the effect of water physicochemical parameters on the nipa palm fruit size by physical comparison of the size of the nipa palm fruit. Besides, the water quality monitoring can act as an indicator for the farmer to find a suitable place for nipa palm to grow. Furthermore, this system can also be used to monitor water quality for various water, including potable water, drinking water, irrigation water, and others.

## 1.5 Project Outline

The study comprises of five chapters. The brief details of each chapter are mentioned below:

Chapter 1 composes of the project background, problem statement, objectives, scope, and the project outline.

Chapter 2 lays out an overview of the studies related to the project that are needed to fulfil the first objective which involved the process of investigating the water quality system. A research gap has also been created to compare the methodology, results and limitations based on the literature review.

Chapter 3 contains the necessary methodology to achieve the second and third objectives. This chapter also explains the model design, coding and the operational mechanism of the water quality monitoring system using IoT for agriculture industries (near nipa palm).

Chapter 4 describes the outcomes of the project which include the completed design of the water quality monitoring system using IoT for agriculture industries (near nipa palm). The findings from the application of the project are displayed in this chapter.

Chapter 5 concludes the overall project and summarizes the achievement made once the project was finalized. Furthermore, it also contains future studies and recommendations.

## 1.6 Summary

In conclusion, this chapter has introduced the study's background and the problem that needs to be solved after completing the project and explains the tasks to be accomplished in each chapter.

# Chapter 2

# LITERATURE REVIEW

## 2.1 Overview

This chapter will explain in detail research relate to this topic about water quality monitoring system for agriculture (near nipa palm). This will include IoT, agriculture relationship with IoT, water quality parameters, recent research related to nipa palm and limitation on recent research related to water quality monitoring system.

## 2.2 Internet of Things (IoT)

The Internet of Things (IoT) is a way for the physical things in daily life to connect with the internet, which mean IoT does not limit the endpoints to computers such as PCs and servers, but to embedded computer systems and the embedded sensors. For example, refrigerator, oven, and other things can connect to IoT. The IoT devices placed in these physical objects fall into two main categories: switches (used to send commands to other objects) and sensors (used to collect and send data). With the data collected by these connected gadgets and automated systems, this data can be analysed to help complete tasks or learn how to optimise a process. Figure 2.1 shows the diagram of IOT that visualize IoT technology can be found in an increasing variety of industries, such as healthcare, manufacturing, transportation and logistics, retail, municipal, agricultural, and finance.

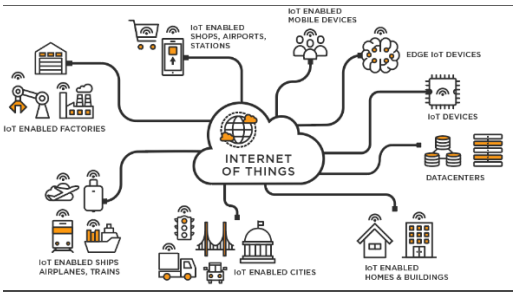


**Figure 2.1**: Internet of Things (IoT) [10]

### 2.2.1 Agriculture in IoT

IoT plays a significant part in "smart agriculture." Conventional farming practices are the focus of the applications of the Internet of Things in agriculture [11]. These applications are designed to help conventional farming practices keep up with rising demand and cut down on output losses. According to a report conducted by BI Intelligence, the number of Internet of Things devices utilised towards the agricultural sector is expected to rise by 20% per year until it reaches 75 million in the year 2020 [12]. Often the IoT in agriculture uses drones, remote sensors, robots, and analytical tools to facilitate monitoring crops, measuring, and mapping fields, and providing data to farmers to develop sound farm management plans, which helps save time and money. In addition, the Internet of Things will intelligently record everything required for quality and quantity monitoring in agricultural areas by utilising sensors. Despite this, farmers can now monitor the state of their fields from virtually any location using IoT-based solutions. Figure 2.2 show a smart agriculture that utilise IoT technology that monitoring several environmental factors, power usage, and visualise of the reading in user-friendly format.

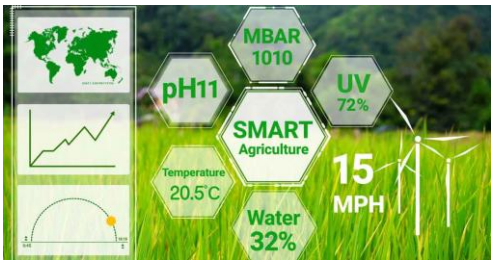


**Figure 2.2**: Agriculture in IoT [13]