SSRG International Journal of Electronics and Communication Engineering Volume 11 Issue 2, 24-32, February 2024
ISSN: 2348-8549/ https://doi.org/10.14445/23488549/IJECE-V11I2P103 

*Original Article*

# Development of An IoT-Based Ecological Aspect Monitoring System for Tor Douronensis Farming

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Received: 25 November 2023 Revised: 01 December 2023 Accepted: 25 December 2023 Published: 02 February 2024

***Abstract** - This research describes the creation of an IoT-based ecological aspect monitoring system for Tor Douronensis farming. The Semah fish (Tor Douronensis) is a highly endangered aquatic ecosystem component. Conservation and sustainable aquaculture require monitoring and managing Semah fish farming's ecological features. The suggested monitoring system uses Internet of Things (IoT) technology for the purpose of gathering real-time data on Tor Douronensis' ecological characteristics. Sensors detect water quality, temperature, dissolved oxygen levels, pH, and other environmental parameters that affect fish health and habitat. The collected data is analyzed and processed on a cloud platform. The IoT-enabled technology lets fish growers, researchers, and conservationists remotely monitor and assess ecological conditions. This IoT-based ecological aspect monitoring system ensures sustainable conservation and aquaculture of Tor Douronensis by precisely and continuously monitoring farming methods. This method protects the endangered Semah fish and aquatic habitats by encouraging ethical fish farming. This research provides valuable insights for improving IoT-based aquaculture and wildlife conservation solutions.*

***Keywords** - Ecological aspect, Monitoring system, Semah fish, Water quality parameters, IoT-based.*

## 1. Introduction

Fish is a food source that is high in protein, which is needed for human food, and fish is an alternative to meat, which has high protein. Indonesia has diverse fish from various waters, one of which is fresh water. The native freshwater fish species in Indonesia are very diverse and potentially germplasm; of the different native species that exist, some species have fallen into the category of species that are prone to extinction [1].

Indonesia has a rich array of native freshwater fish species, sometimes referred to as "indigenous," that have promising prospects for cultivation as both consumable and decorative fish. The Golden Mahseer (Tor putitora), commonly known as Semah, is a large and ecologically significant freshwater fish species found in the rivers and streams of the Indian subcontinent. Renowned for its impressive size, vibrant colours, and strong swimming ability, Semah plays a crucial role in maintaining the ecological balance of aquatic ecosystems [2, 3].

The term "Mahseer" is often used to refer to a collection of freshwater fish species that have significant economic and ecological value in the Asian region [4]. There are three general mahseer fish: Tor, Neolissochilus, and Naziritor. However, species in the genus Tor are usually called "true mahseers." Toros species are famous for sport fishing, are very valuable as food, and are essential to people in South and Southeast Asia's religions and cultures. Although these fish are significant, their numbers have been going down in the wild because their homes are being destroyed for electricity dams. Moreover, biological uncertainty has made it harder to protect Tor [5].

Fish of the semah species can be found in South Sumatra's Selabung River and Lake Ranau [6]. Although this fish species is found in Sumatra, Kalimantan, and Java, it is more well-known in South Sumatra, Jambi, and West Sumatra. Other regional names for the fish known as "semah" include "kancera" in West Java, "garing" in West Sumatra, "silap" in West Kalimantan, and "padak" in Jambi and South Sumatra. This species of fish is valued economically in Sumatera since the locals like it.; because the public favors it. The several species of semah fish that may be found in the waters of Kerinci, which are located in the province of Jambi, are illustrated in Figure 1. This variety of fish is threatened with extinction in public waters in the Jambi region since it has not been cultivated, and environmental changes and fishing are fast. Fisheries and environmental changes continue without action. This fish species is scarce because individuals are not used to catching seeds in public waterways and are not informed on cultural technology. Public waterways and uneducated primary horticulture technology can be used [7].

Aquaculture, or fish farming, supplies much of the world's food and many communities' income. However, the industry's rapid growth has caused pollution, habitat loss, and disease outbreaks. Improve aquaculture methods to be more sustainable. Technology to improve aquaculture efficacy and sustainability has garnered attention in recent years [8]. The IoT is an example of a technology that encompasses the integration of various hardware, software, and sensor systems to facilitate the gathering and examination of data [9, 10].

Southeast Asia is home to the Semah Fish, sometimes referred to as Empurau, a rare and highly prized freshwater fish species. The parameters pertaining to water quality, including levels of dissolved oxygen, temperature, and pH, which are crucial for optimum fish growth and survival, are monitored and analyzed using the ecological aspect monitoring system described in this work [11-13].

There have been multiple reports of research that make use of IoT by employing the Thinger.io IoT Server [14, 15]. Multiple sensors are employed, each of which is connected to the Internet of Things device. This configuration allows the information acquired from the sensors to be processed, shown on the LCD, and transmitted to the handheld device.

**Fig. 1 Semah fish (Tor Douronensis)**

The objective of this study is to provide a thorough comprehension of the complexities associated with the creation and execution of an IoT-based Ecological Aspect Monitoring System for Tor Douronensis aquaculture. By undertaking this action, the objective is to establish a pathway for the cultivation of Tor Douronensis in a manner that incorporates advanced technology, promotes sustainability, and demonstrates ecological responsibility. This initiative seeks to meet the increasing requirements for precision and environmental awareness in contemporary aquaculture methods.

## 2. Ecological Aspect of Fish Growth

Ecological studies look at how living things connect with their surroundings and with other living things. Ecology is the study of behavior that affects the world and nature, including actions that have results or actions that help or hurt living things. Aquatic ecology studies all of these settings because they have different kinds of communities, from the most minor individuals to the whole ecosystem. Animals that live in marine environments include fish [16-18].

The benefit of aquatic ecology in the field of fisheries is the ability to determine various limiting factors or parameters as a benchmark for organisms that live in it. The density and diversity of an organism in an aquatic ecosystem can be determined based on the following parameters [19, 20].

### *2.1. Physical Parameters*

#### *2.1.1. Temperature*

Brightness and depth affect water temperature. Temperature affects species dispersion because organisms occupy a temperature environment based on cell activity. Temperature increases viscosity, chemical reactions, evaporation, and volatilization. As temperature rises, dissolved oxygen levels fall, reducing oxygen for metabolic activities and fish respiration. Thus, fish are more prone to disease at lower temperatures [21]. A comprehensive investigation examining the impact of aeration rate on fish growth was conducted under controlled conditions with a temperature range of 23.0-26.8°C.

The study's maintenance media temperature range is suitable for mahseer fish fry culture. Mahseer fish species live in 22-30˚C environments. 23.0-26.8˚C is ideal for freshwater fish rearing [22, 23].

#### *2.1.2. Brightness*

Brightness is a physical parameter that is closely related to the photosynthesis process in an aquatic ecosystem. High brightness indicates the penetrating power of sunlight deep into the waters. Brightness is a measure of water transportation, which is determined visually using a secchidisk.

#### *2.1.3. Odor and Color*

The problem that often occurs is the emergence of disease attacks starting because of changes in the color of the pond water caused by the death of several types of plankton. The water changes from a green color to a brown color; untreated ponds will be brown [24].

### *2.2. Chemical Parameters*

#### *2.2.1. Disolved Oxygen*

Dissolved Oxygen (DO), also referred to as dissolved oxygen, is a chemical measure in aquatic environments that quantifies the concentration of oxygen dissolved within the ecosystem.

DO very cold water contains less than 5% oxygen, will decrease if the water temperature increases, and will reduce if utilized for respiration and chemical decomposition in water. Waters with high $O_2$ levels will cause a high diversity of organisms. If $O_2$ decreases, only tolerant microorganisms can live in that place. Oxygen levels in eutrophic waters during the day will be increased due to the large number of phytoplankton and plants that photosynthesize.

Conversely, at night, all organisms in the water, including phytoplankton, will utilize oxygen in the water for respiration. This is what causes fluctuations in oxygen levels in these waters [10, 11]. The optimal concentration of dissolved oxygen in fish farming is typically 5 mg/L, as this falls within the recommended range for the cultivation of fish fry in aquatic environments [23].

*2.2.2. pH*

pH, which stands for “degree of acidity,” is a chemical measure that tells us how many hydrogen ions are in water. The chemical processes that happen in water can be changed by the amount of hydrogen ions present. The percentage of hydrogen ions (H+) in a solution is used to calculate the pH scale, which tells you how acidic or basic a solution is.

It is calculated using the formula pH = -log (H+). Pure water consists of H+ and OH- ions in balanced amounts until the pH of pure water is usually 7. The more OH- ions in the liquid, the lower the H+ ions and the higher the pH.

Such liquids are alkaline liquids. Conversely, the more H+ ions, the lower the pH, and the liquid is alkaline. Fish belonging to the tor species, including tor soro, have sperm that can develop well with a pH ranging from 7.6 to 7.9 [25, 26].

*2.2.3. Salinity*

Salinity indicates the salt content of a body of water. Salinity is the distinguishing feature between freshwater and saltwater ecosystems. Salinity refers to the collective concentration of dissolved solids in water subsequent to the conversion of carbonates into carbon dioxide, the substitution of bromide and iodide ions with chloride ions, and the removal of all inorganic substances as dioxide.

Salinity is quantified using the measures of grams per kilogram (g/kg) or parts per thousand (%). The salinity value of fresh waters is usually less than 5% brackish waters between 0.50%-30% and marine waters 30%-40%. In coastal waters, the value of salinity is strongly influenced by the influx of fresh water in the river. The salinity can be measured by using a device called a refractometer or salinometer.

The chemical parameter standards for fish farming water quality based on PP No. 82/2001 (Class II) are Biochemical Oxygen Demand (BOD) < 3 mg/L; Ammonia ≤ 0,02 mg/l; Phosphate max. 0,2 mg/L; pH 6-9; Total Dissolve Solid (TDS) ≤ 1000 mg/L; Nitrate max. 10 mg/L; and Dissolved oxygen (DO) > 4 mg/l.

### *2.3. Biological Parameters*

A plankton is a small plant or animal creature whose life floats in the water and is always carried away by the current. Plankton cannot swim as actively as free swimmers, such as fish, shrimp, squid, and whales.

Plankton are organisms or microorganisms that live freely in waters such as freshwater, brackish, and marine waters. Plankton consists of the remains of marine animals and plants. Although it is a kind of living thing, plankton does not have the strength to fight against currents, tides, or winds that wash it away because of its small size [27].

## 3. Cultivating Semah Fish

Fish farming, also known as aquaculture, is a carefully managed practice aimed at the preservation, cultivation, and propagation of fish species within a controlled setting, with the ultimate goal of sustainable harvests. Aquaculture, also referred to as fish farming, encompasses fisheries enterprises that engage in the cultivation of fishery products. [28].

Semah fish cultivation requires ideal water quality for growth, which has a temperature of 21-25˚C, turbidity below 25 Jackson Turbidity Units (JTU), dissolved oxygen above 5 mg/L, pH level ranging from 6.5 to 8.5, Carbon Dioxide ($CO_2$) content ranging from 2.2 to 4.5, water hardness of 12.3 mg/L and ammonia content of 0.0-0.1 mg/L.

Before the seeds are spread, the pond needs to be processed, given lime (if the pond soil was previously acidic), and sprinkled with 1 $Kg/m^2$ of manure. Don’t forget that the pond bunds must also be repaired so that they don’t leak. When the preparation is complete, the pond is then filled with water to a level of 30-40 cm.

A week later, the fish fry can be stocked. In order to avoid stress, it is necessary to carefully acclimatize the fry, adjusting the temperature of the pond water to the water in the fry container. Leave the seed container (plastic bag) in the pond for a while. Next, the bag is opened and tilted, allowing the fry to emerge from the container.

## 4. Prototype Design and Implementation

Figure 2 depicts the schematic representation of the component layout inside the prototype enclosure, while Figure 3 illustrates the wiring configuration of all the constituent components comprising the prototype.

The components employed in this prototype include the Arduino board, DHT22 humidity sensor, DS18B20 temperature sensor, DO sensor, and pH sensor.

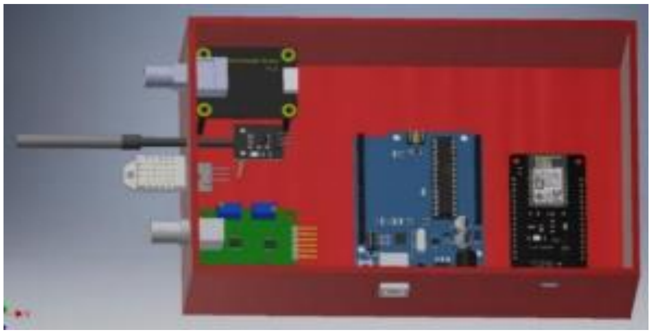

**Fig. 2 The box design for prototype**

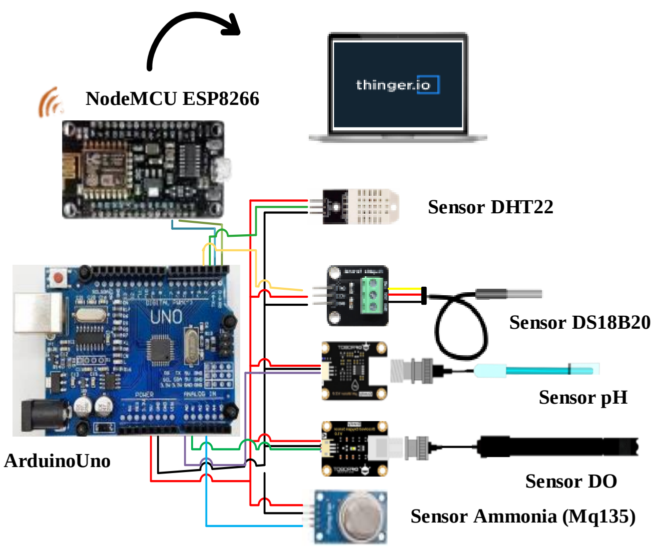


**Fig. 3 The design of electronic wiring**

The C language is used to communicate programming commands with the Arduino board [29, 30].

In Figure 3, it can be seen how the fish pond water control works as a whole, which starts with Arduino as a data processor. Data obtained from sensors where the pH sensor functions as a reader of acidity in water, the Do sensor reads dissolved oxygen levels in water, DHT22 sensor as a reader of ambient air temperature and humidity, DS18B20 sensor as a reader of temperature in water, and MQ135 sensor as a reader of Ammonia gas ($NH_3$) then the data from the Arduino microcontroller will be transferred using the esp8266 module to the cloud system to be processed on web services and then sent to the Thinger IO website on the android smartphone the data obtained is sent in real-time to the control station. These data will then also be available online, which can be accessed in real-time from anywhere, anytime, and as long as there is an internet connection.

The process flow chart for the updating of sensor data in the cloud is represented in Figure 4. The sensor's reading is uploaded to the cloud and shown on the device's associated LCD in real-time.

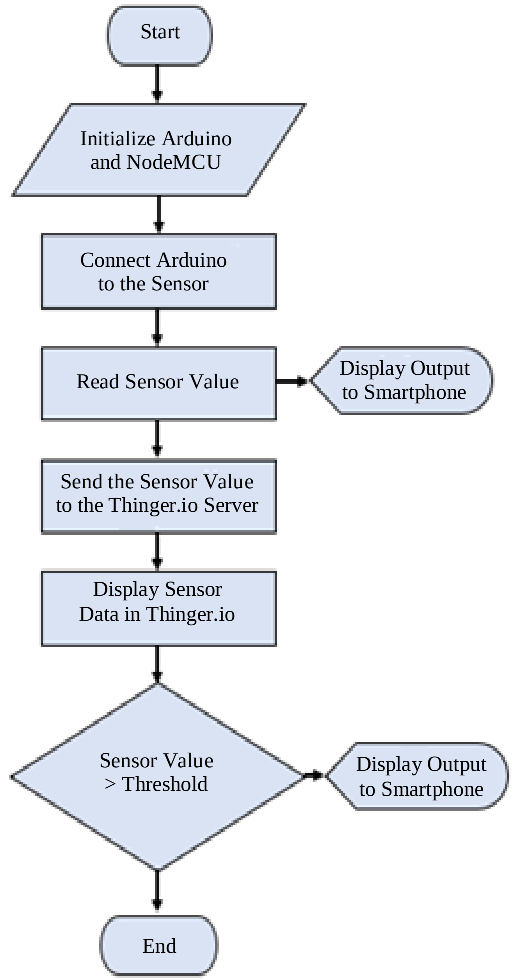


**Fig. 4 The flow chart for sensor data updation**

## 5. Results and Discussion

The integration of the Thinger IO application service functions to control the ESP8266 microcontroller, which is accessed via a wireless transmission medium connected to a hotspot. Thinger IO becomes software that controls and monitors the components of the water quality monitoring system using the buttons located on the Thinger IO website with commands that have been previously programmed in the Arduino IDE.

By using the esp8266 module, the microcontroller can connect to the cloud via the internet network. It can then use the Thinger IO website, which allows users to monitor and control water quality monitoring tools remotely. The performance of the system that has been made can fulfill all functional requirements.

In the test results, there is a delay of about 1-2 minutes when receiving commands from the application to the device; this is because the reception of data on the device takes about 12 ms. NodeMCU can connect to the Thinger IO cloud website via an ethernet shield attached to the internet. Ping to the Thinger IO cloud website server is 12 ms, which makes data reception and transmission slow; this is due to the ISP factor used.

Thinger IO website testing is a test carried out on an android phone or computer by entering the Thinger IO website address, namely https://thinger.io on Google, which then enters the template address that has been designed to monitor and send commands to turn on the device and send data from the Arduino microcontroller for sensor readings via the website so that when the application is connected to the microcontroller, we can see on the large microcontroller serial monitor ping to the Thinger IO cloud website server. So that the data received could be processed and displayed on the thinger io website.

As shown in Figure 5, the equipment panel box is mounted on a pole, and the sensors are placed around the pond in accordance with their intended purposes and operations; the water temperature, pH, and DO sensors are submerged in the water being monitored, while the ambient temperature and ammonia sensors are placed outside the pond area.

**Fig. 5 Experiment test setup**

Figure 6 illustrates the findings obtained from a two-day testing period, indicating that the recorded ambient air temperature fluctuated between 24.1°C and 29.9°C. Specifically, the air temperature exhibited an upward trend from 8:00 am to 5:00 pm, followed by a subsequent decline from 5:00 pm to 8:00 am.

Additionally, a midday increase in temperature was observed, which was subsequently followed by a decrease in the afternoon. This phenomenon is impacted by solar radiation, environmental temperature, human activities, climate change, and geographical circumstances.

The sensor used is the DHT22 sensor, which has the capability to detect temperatures ranging from -40 °C to 80°C. It exhibits an accuracy of ± 2°C and operates at a sampling rate of 1 Hz, therefore capturing one sample each second. Furthermore, this sensor exhibits a notable degree of precision, and it also has a commendably low level of energy consumption, making it very efficient for practical applications.

According to Figure 7 in the experimental findings conducted over a span of two days, the atmospheric humidity around the fishing pond was seen to fluctuate between 75.70% and 99%. Specifically, during the hours of 00:00 and 2.50 pm, the humidity levels ranged from 90% to 95%. Subsequently, during the period of 2.50 to 5.30 pm, the humidity exhibited a decline, reaching about 80% to 90%.

The data shows a further rise from 5:30 pm to 09:00 am, with values ranging between 90% and 100%. Subsequently, there is a reduction seen from 09:00 to 11:00, with values ranging between 75% and 90%. The used sensor is the DHT22 sensor, renowned for its exceptional precision.

This sensor is capable of measuring a wide range of humidity levels, spanning from 0% to 100%. Consequently, it is adept at gauging humidity levels throughout the whole spectrum, from very arid situations to fully saturated environments. As a result, it is highly ideal for many applications.

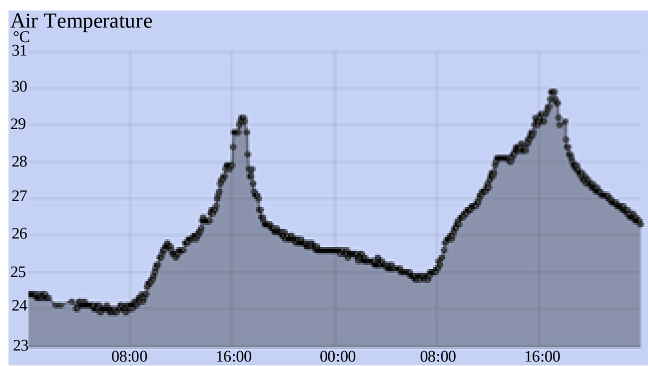


**Fig. 6 Air temperature measuring display**

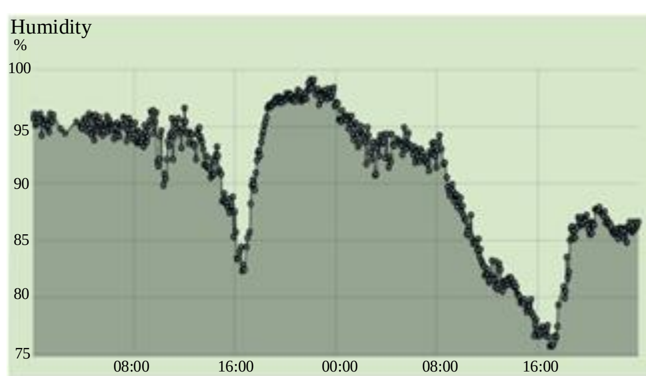


**Fig. 7 Air humidity measuring display**

After testing the pedestal for two days, the Dissolved Oxygen sensor reading is constant at 5 mg/L, which is below fisheries water quality standards of >4 mg/L (Figure 8). The water tested is suitable for aquaculture. The sensor employed has a reaction time of < 45 s. Where the sensor responds swiftly at 20°C. So, the sensor is helpful in monitoring fishery water quality, but it needs maintenance and calibration to get reliable measurement data.

The MQ-135 sensor, which detects ammonia gas, sulfur compounds, benzene, Carbon Monoxide (CO), and alcohol gas concentrations, was shown in Figure 9; the sensor did not detect ammonia gas around the fishing pond. The sensor can detect dangerous gas leaks and monitor air quality. This sensor can detect multiple dangerous gases; hence, it is difficult to calibrate to monitor one kind of gas. Also, ambient circumstances severely affect this sensor, causing unreliable results. Due to its short lifespan, this sensor must be replaced. This sensor is sensitive to corrosive gasses and has a restricted detection range.

The underwater temperature measurement is shown in Figure 10. The testing have been carried out for 2 days; it can be seen in the results of sensor readings where at 00.00 - 4.00 pm, the measured temperature is 23.5˚C. at 4.00 - 4.30 pm, the temperature has increased, namely 24˚C. From 4.30 - 11.52 pm, the temperature increased to 24.5˚C. Changes in water temperature have a significant impact on aquatic ecosystems. Increased water temperature can affect the reproduction and behavior of marine organisms, change the distribution of species, and disrupt the overall balance of the ecosystem.

Research on fisheries temperature standards explains that the ideal temperature for fisheries ranges from 23.0˚C to 26.8 °C, so the temperature on the test object is suitable for aquaculture. The sensor used is the DS18B20 sensor where this sensor is able to read temperatures of -55 ~ + 125˚C. In the temperature range of -10˚C - 85˚C the sensor accuracy reaches 0.5˚C. This sensor is suitable for use in fisheries water quality monitoring activities.

Figure 11 at the time of the pH sensor measuring instrument experiment for 2 days, it can be seen that the pH value ranges from 5.55 to 6.72. In the chemical parameters of fish farming water quality standards, the pH standard in suitable fishery water is 6-9.

So it can be observed that in the water experiment, the pH value is close to the normal value of fisheries, but fish farmers must carry out methods in stabilizing the pH value suitable for aquaculture; the sensor reads a fluctuating value where this is caused by several factors including the changing presence of hydrogen ions (H +), High Sensitivity of the pH Sensor where the sensor used has a response time of less than 2 seconds, besides that External Interference also affects sensor readings including changes in temperature, pressure, or contamination.

When the temperature increases, it can affect the activity of hydrogen ions in the solution and cause fluctuations in pH. The use of this pH sensor requires regular calibration using a pH standard solution to ensure the accuracy of the sensor reading. The dashboard showing the appearance of the graphical display of the measurement of the characteristics of ecological elements on the IoT platform can be seen in Figure 12.

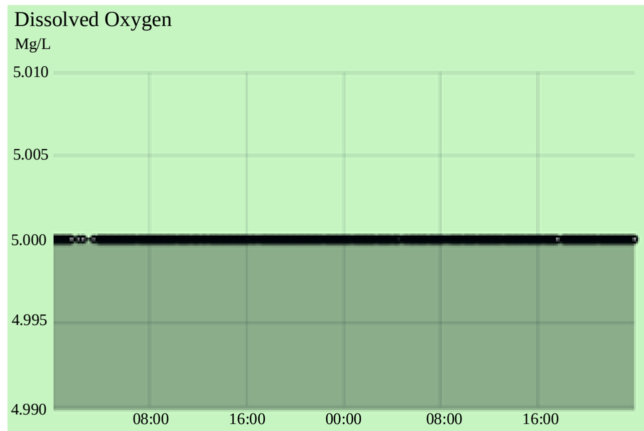


**Fig. 8 Dissolved oxygen level measurement display**

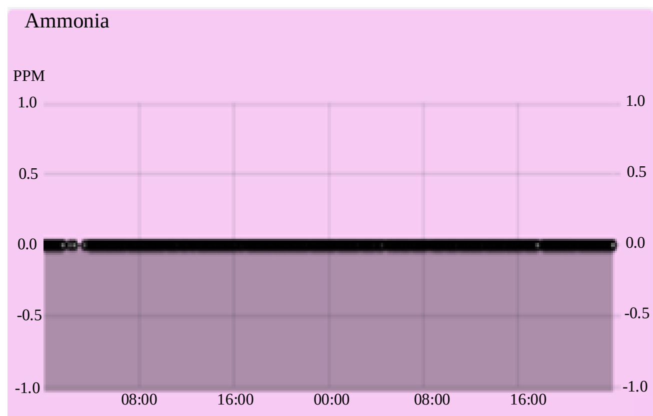


**Fig. 9 Ammonia gas measuring display**

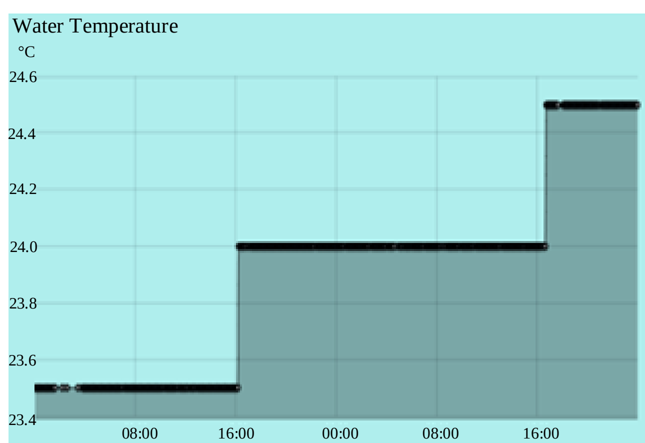


**Fig. 10 Underwater temperature measurement display**

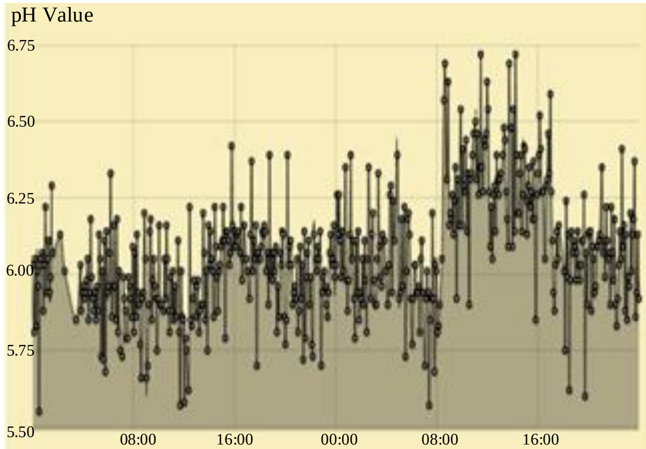


**Fig. 11 Display testing the pH level of water**

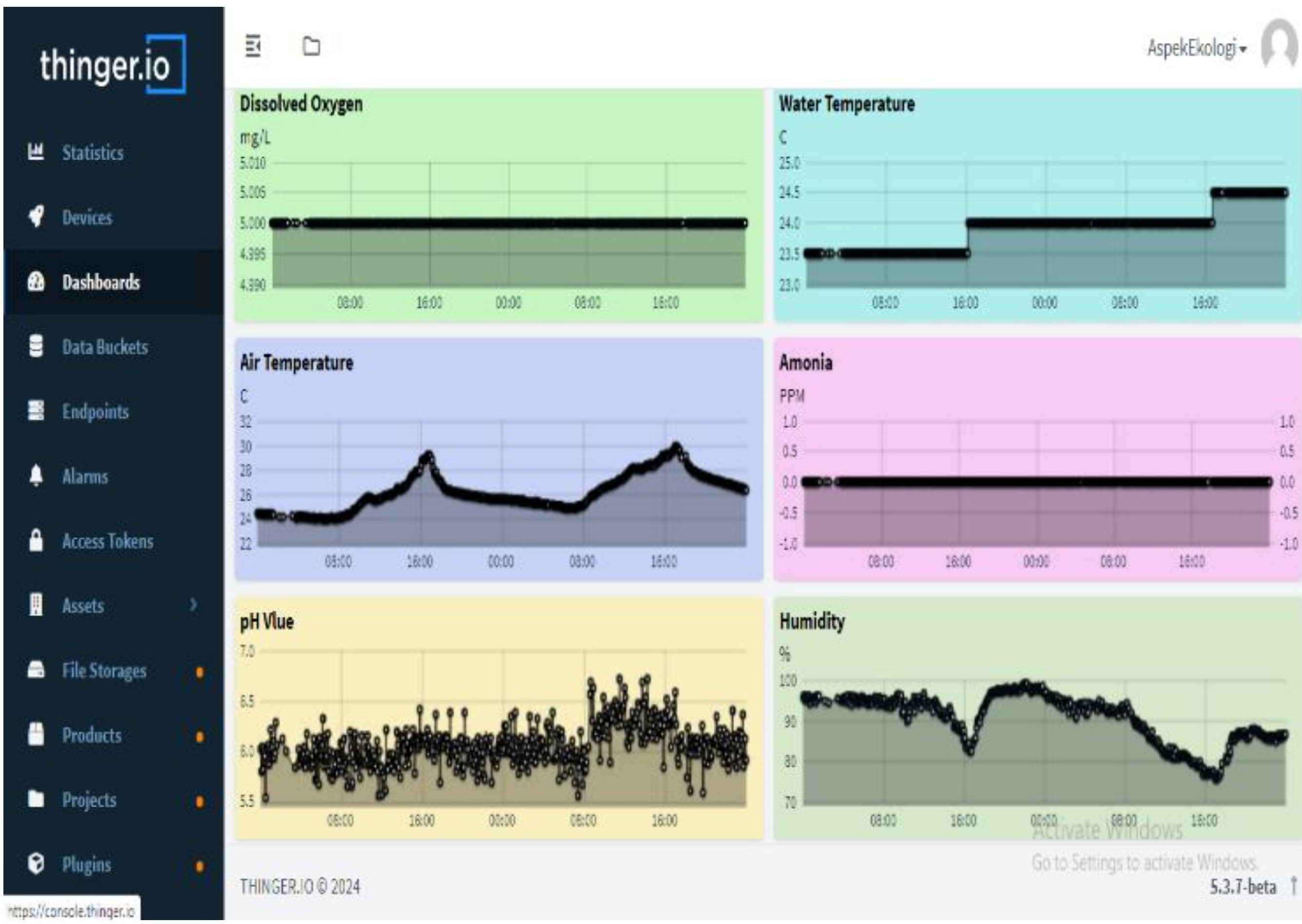


**Fig. 12 The dashboard of the ecological aspect measurement**

## 6. Conclusion

The implementation of the ecological aspect monitoring system for Semah fish farming, which makes The use of IoT technology in the environmental aspect monitoring system for Semah fish farming, has shown its potential to improve the efficiency as well as the long-term viability of fish farming techniques.

The ability of the system to collect and analyze real-time data on parameters relating to water quality, levels of dissolved oxygen, temperature, and pH offers valuable insights into the ecological aspects of fish farming. These insights enable appropriate actions to be taken in order to maintain the best conditions possible for fish growth and survival.

## Funding Statement

This publication is financed with the subsidy granted to the University of Negeri Padang, for their support in the context of the Pengabdian kepada masyarakat Scheme.

## Acknowledgments

The authors wish to acknowledge the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, as well as the Institute for Research and Community Services of the University of Negeri Padang.

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