Synthesis of Micro-Algae Micro-Sample Using Lamp Light Source from Solar Panel and Integrated to Internet of Things

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Abstract. This research aims to develop a method for synthesizing microalgae samples using light from lamps powered by solar panels and integrated to Internet of Things (IoT) technology to monitor seawater temperature and pH value as the synthesis medium. The system is designed to create an optimally controlled environment for microalgae synthesis. It introduces a new approach to managing habitat variables, aligning with green technology principles, and optimizing the quality of microalgae. The artificial environment, powered by photovoltaic (PV) solar energy, ensures sufficient energy supply for the synthesis process. Temperature and pH sensors in the IoT system are connected to a microcontroller, with data stored on a website for analysis. The system monitors temperature within the range of 26.4°C-28.4°C, with an error margin below 1%, maintains a pH level between 5.6 and 6.2 with a similar error margin, and produces approximately 3 mg/l of biomass. The results confirm that IoT technology effectively monitors the synthesis environment for microalgae samples.

Keywords: Internet of Things, Micro-algae, Synthesis

1 Introduction

The population growth continues to soar from year to year, food availability has become a problem in life. We face the problem that creating sustainable food security is essential to support the growing global population. Nutritious food is crucial for human development, ensuring individuals remain healthy and productive throughout their lives. As the population continues to rise, competition for land between food production and other uses will intensify. To address this, a strategic approach to food security is necessary, ensuring access to safe, sufficient, and high-quality food for everyone. Food security involves various elements, including food production, distribution, and

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accessibility. This research focuses on the significance of high-quality microalgae for use in the food and bio-pharmaceutical industries (Anggreni, 2021; Azimatun, 2014). Various research institutions in Indonesia are currently focusing on studies related to microalgae, a bluish-green organism that thrives in both seawater and freshwater environments. Often regarded as a highly nutritious food source, microalgae are rich in essential nutrients and contain a significant amount of protein. In addition to their role in food, microalgae offer benefits for beauty and health. Due to the growing demand for microalgae, their production is increasingly carried out in controlled indoor environments, such as laboratories or industrial settings, through microalgae synthesis (Anggreni et al., 2021). Given these conditions, the synthesis of microalgae requires an energy source to illuminate the growth and development medium, replicating its natural habitat, while also monitoring key factors like water pH and temperature. In this research, solar panels (PLTS) are used as a renewable and sustainable energy source, integrated with Internet of Things (IoT) technology to monitor and record data on the artificial environment in which the microalgae are synthesized. Previous studies have shown that light intensity can affect both the growth and the qualitative composition of microalgae. By combining renewable energy systems like PLTS with IoT technology, a controlled environment can be created that enhances the quality of microalgae samples. This research enhances the understanding of how variables like light intensity can be optimized to improve the composition of microalgae samples. A study by Bialevich et al. (2022) titled “The Effect of Variable Light Source and Light Intensity on the Growth of Three Algal Species,” highlighted that light serves as a crucial energy source for autotrophic organisms such as microalgae. Both the intensity and quality of light significantly impact cell growth and biomass composition. The study examined three species of algae (Chlamydomonas reinhardtii, Desmodesmus quadricauda, and Parachlorella kessleri) to assess how different light intensities and spectra influenced their growth, using cultures grown under three varying light intensities and sources (Bialevich et al., 2022).

1.1 Solar Panel

A solar panel is a device made up of solar cells that transform light into electrical energy. These panels are commonly referred to as photovoltaic cells, with “photovoltaic” meaning the conversion of light into electricity. Photovoltaic systems are also known as solar cell modules or panels (Widharma, 2021; Suputra, 2017).

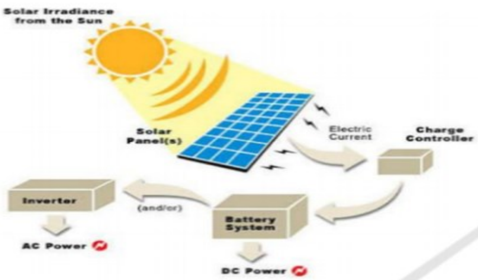

Figure 1. Schema of solar panel

This device converts sunlight into electricity by generating a flow of electrons within the cell module, driven by differences in electron concentration. This flow produces direct current (DC) electricity, which can be used to charge a battery according to the necessary voltage and current specifications. To power alternating current (AC) devices with the stored DC electricity, an inverter is required to convert DC into AC. It is important to match the power requirements of the solar panels, inverters, and batteries accordingly (Pranata, 2022; Rochadiani, 2022).

1.2 Internet of Things

The term "Internet of Things" (IoT) was first used in 1999 by British technology pioneer Kevin Ashton to describe a system in which objects in the real world can be connected to the Internet with the help of sensors. Today IoT has become a popular term to describe scenarios where internet connectivity and computing capabilities can cover a wide variety of objects, devices, sensors, and everyday items (Arta, 2022; Pranata, 2022).

Figure 2. Schema of Internet of Things

The ESP32 is a system-on-chip (MCU) micro-controller unit from repressive with dual-mode 2.4 GHz WiFi and Bluetooth connectivity, an ultra-low power chip, and several peripherals. The ESP32 functions as a controller and as a data sender from the modular application on the user's cellphone for monitoring synthesis. Module The output section is the part that functions to display data that has been processed by the ESP32 micro-controller. The output results are data displayed on the DC Pump application, LCD and relay connected to the load. This research uses an ESP32 and Arduino IDE software to program the micro-controller (Arta, 2022; Suputra, 2017).

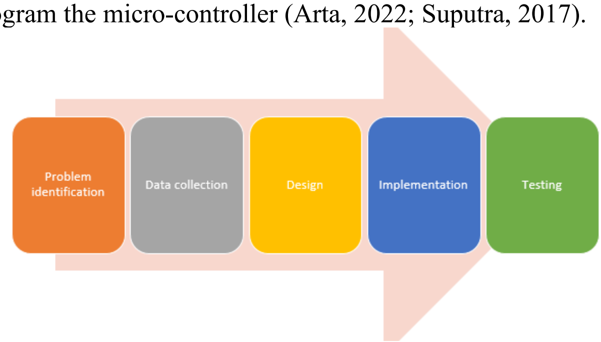

Figure 3. Diagram of research

2 Methodology

The objectives of this research are to design a PLTS system that is integrated with IoT for the synthesis of micro-algae micro-samples, and can determine the effect of light on the biomass of micro-algae micro-samples. The research flow diagram is shown in Figure 3. Starting from a survey and collecting seawater as a medium for micro-algae synthesis, preparation of consumables and equipment, and design of PLTS and IoT systems. Making micro-algae micro-samples in seawater media. PLTS is a source of energy for lights and aerators. IoT for monitoring the temperature and pH of seawater in containers which are recorded in a spreadsheet table (Suputra, 2017; P3M, 2021).

2.1 Solar Panel System

As previously mentioned, solar panels play a key role in converting sunlight, specifically photons, into electrical energy through the photovoltaic effect. Only the sunlight absorbed by the silicon layer is converted into electricity, while the remainder is lost as heat or reflected away. The total electrical energy output of a solar power system (PLTS) is determined by the combined performance of all its components. The system's maximum power output, known as watt peak, can be calculated using a specific equation (Nurjaman et al., 2022).

$$Energy\ produced\ by\ the\ module\ =\ Load\ Energy\ \times\ 130\% \quad (1)$$

Assuming a forecast increase in load of 30%. So after getting the Total Energy module, we have to determine the lowest average daily irradiation, lowest daily irradiation data, then you can find how much PV capacity must be provided using the following equation.

$$Ptotal\ =\ (Energy\ module\ /\ Gavg)\ \times\ Gstc \quad (2)$$

In selecting the PV module that will be used in this planning analysis, the level of module efficiency is the main factor that must be taken into account, because the greater the efficiency, the greater the power that will be produced. To determine the maximum number of PV to be installed, you can use the following formula.

$$Number\ of\ PV\ =\ (Ptotal\ /\ Pmax)\ PV \quad (3)$$

SCC (Solar Charge Controller). To calculate SCC specifications, use the following equation.

$$Iscc\ =\ Isc\ panel\ \times\ number\ of\ PV \quad (4)$$

To count the number of SCC needed in a PLTS, you can use the following equation.

$$Nscc = \frac{Total\ Wp}{Maks\ Output\ SCC} \quad (5)$$

Battery. To determine the battery capacity in a PLTS system, it can be calculated using Equation (6).

$$Ah = \frac{N \times Ed}{Vs \times DOD} \tag{6}$$

Protection Components. In the PLTS system, all components work in DC, while the AC system works from the inverter output to the AC load distribution. Protection is used to minimize the risk of failure of the PLTS system, for DC systems it uses protection in the form of a fuse. To determine the fuse used to connect the solar panel to the SCC:

$$Rating\ of\ voltage = 1.2 \times Voc \times number\ of\ PV \tag{7}$$

$$Rating\ of\ current = 1.4 \times Ioc \times number\ of\ PV \tag{8}$$

2.2 Internet of Things Monitoring System

The ESP32 microcontroller is the main component for processing data from input. The DC step-down module is used to reduce the DC 12V voltage to 5V. The DS18B20 temperature sensor is used to measure water temperature parameters. The pH sensor is used to measure water pH level parameters. Measurement results by IoT and conventional will be compared to know how good all of the monitoring activities, meanwhile from research results can be known how good micro-sample micro-algae growth with this condition of water media temperature and pH belongs the monitoring synthesis.

3 Result and Discussion

3.1 Result

Solar Panel System. This research involves designing a solar panel system using components such as a 100 WP solar panel, a 12V 20Ah battery, an SCC MPPX, a 6A MCB, a 10W DC lamp, and a 10W aerator. The estimated power consumption is approximately 480 Watt-hours per day. Based on the calculations provided in this study, the solar panel system is designed to supply power for both the lamp and the aerator.

Demand Supply. The total power demand is 20 watts, with 10 watts needed for a lamp and 10 watts for an aerator, each operating throughout the day. This results in an overall energy requirement of 480 Watt-hours per day.

Solar Panel. A 100 WP solar panel, assuming an effective sunlight duration of 5 hours per day, is sufficient to provide 480 Watt-hours of energy daily for both the lamp and the aerator.

Accumulator. A 12V 100 Ah battery is adequate to provide 480 Watt-hours of energy per day for the lamp and aerator.

IoT Monitoring System. The modeling system of monitoring using IoT technology with a single chip micro-controller ESP32 and supported by 2 kinds of sensors, they are one type of temperature sensor and one type of sensor pH has been designed like Figure 3 by improving from many types of research before so that the schema of IoT monitoring system using micro-controller ESP32 as a central monitoring system.

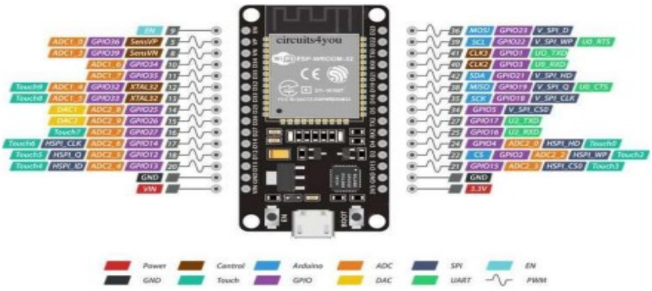

Figure 4. Micro-controller ESP32 as central monitoring system

To monitor pH of water media is using Sensor pH-4502C and meanwhile tool used to measure conventionally is pH meter.

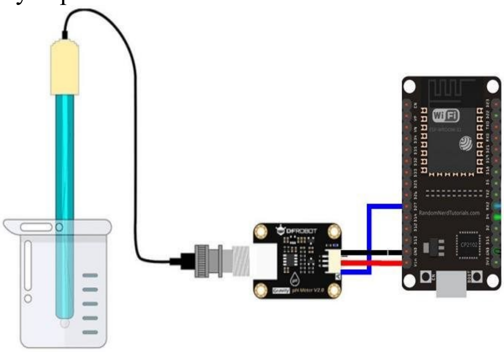

Figure 5. Measurement of Sensor pH

Besides the micro-controller ESP32 as the central monitoring system and Sensor pH-4502C, also supported by a temperature sensor to monitor water temperature in the synthesis. In this research, monitoring water temperature is using sensor DS18B20 and meanwhile tool used for conventional measures is an infrared temperature soft-gun. Measurement results by IoT and conventional will be compared to know how good all of the monitoring activities, meanwhile from research results can be known how good micro-sample micro-algae growth.

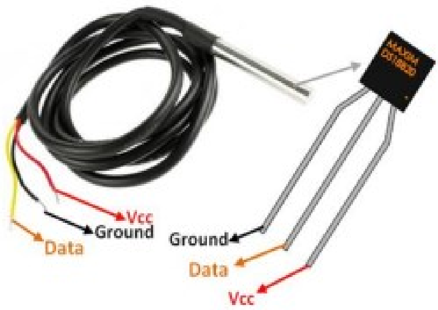

Figure 6. Measurement temperature

Comparison results measurement with IoT and conventional and comparison results measurement with IoT and conventional shown in Table 1.

Table 1. Comparison of measure pH and temperature

No	Time	Sensor	pH meter	No	Time	Sensor	IR gun
1	06	5.9	5.9	1	06	27.3	27.4
2	09	6.0	5.9	2	09	27.4	27.5
3	12	6.1	6.0	3	12	27.6	27.8
4	15	6.2	6.0	4	15	27.7	27.6
5	18	6.3	6.2	5	18	27.6	27.4

Simulation. Designing of monitoring system to temperature and pH of water by using micro-controller and integration with IoT technology is shown in Figure 7. This system then installed to media that full of sea water and nutrition mix as media for the synthesis micro-algae micro-sample.

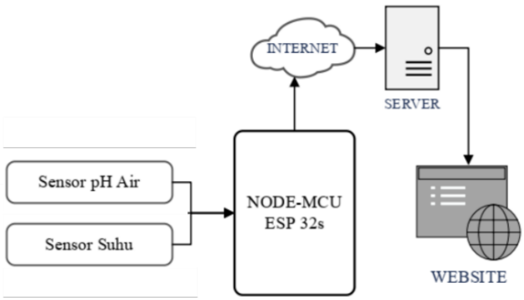

Figure 7. Design of IoT system

Internet of Things (IoT) consists of three main elements in their architecture, they are: hardware with IoT module, connection component to the internet and cloud data as a unit to store application also database. Internet is conduct between the interaction and user is operator and supervisor all the process. Hardware with IoT system is shown in Figure 8.

Synthesis of Micro-algae Micro-sample. In the synthesis micro-algae micro-sample, temperature sensors and pH sensors are installed as synthesis media and then transferred via the internet to Android or smartphone. Besides that also measured by conventional measure tools. They are infrared temperature soft-gun and pH meter at periodically compare their results of measurement between conventional and sensor (IoT) such as shown in Figure 8. This synthesis used 4 media seawater with different various attitudes. Synthesis micro-algae micro-sample done in the 2 dynamics conditions, they are simulated various of times between time for dark 12 hours and time for light 12 hours then using light all day 24 hours. In every dynamics condition, periodically measure to monitor their condition, and analyze the micro-algae micro-sample growth.

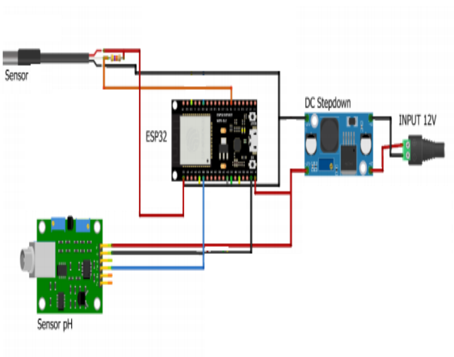

Figure 8. Hardware IoT system

Figure 9. Synthesis of micro-algae

3.2 Discussion

Average of Temperature Weekly. The system was tested weekly from Monday to Saturday to monitor seawater temperature for microalgae synthesis, with observations made on Sunday to assess microalgae growth. Temperature measurements ranged from 26.4°C to 28.4°C, as illustrated in Figure 9. Throughout the week, water temperature varied by 0.1 to 0.6°C. The discrepancy between the sensor readings and those from an infrared temperature gun was less than 1%.

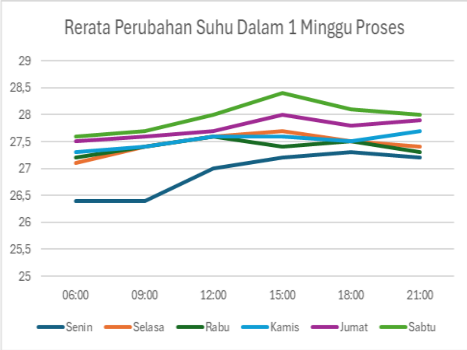

Figure 10. Average temperature change weekly (in Indonesia language)

Average of pH Weekly. Similar to temperature monitoring, the pH value of seawater used for synthesizing microalgae samples was tracked from Monday to Saturday, with observations on Sunday to assess microalgae growth. The pH measurements ranged from 5.6 to 6.2, as shown in Figure 10. During the week-long cultivation, the pH level varied by 0.1 to 0.2. The discrepancy between the sensor readings and those from a conventional pH meter was less than 1%. The microalgae synthesis process yielded samples with a biomass of approximately 3 mg/l.

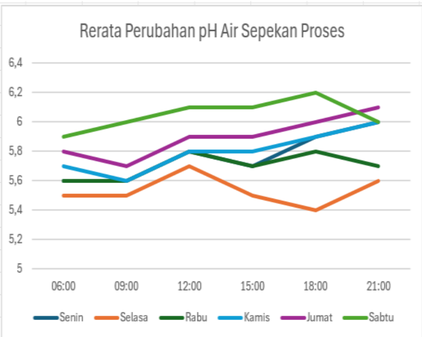

Figure 11. Average pH change weekly (in Indonesian Langauge)

4 Conclusion

Based on data and analysis that can be concluded, designing solar panel and IoT work well to supply and monitoring the synthesis of micro-algae micro-sample. Designed system can build an optimize controlled environment in the synthesis of micro-algae micro-sample. Using temperature sensor and pH connected to micro-controller then store to database obtained optimize result. Temperature of sea water in the synthesis of micro-algae micro-sample is about 26,4°C until 28,4°C with error under 1%, meanwhile pH value is about 5,6 until 6,2 with error under 1% and produce average biomass is about 3 mg/l. To get better results and improve new method need more various attitude in the synthesis of micro-algae micro-sample process sustainability.

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