Phytoplankton Concentration Measurements Base On Arduino Microcontroller

Gunady Haryanto [1,*], *Vector* Anggit Pratomo [1] *Agung* Saputra [1]
[1]Electrical Engineering University of Pancasila, Jakarta, Indonesia

Abstract. In this research is designing and manufacture Phytoplankton concentration measurements in liquid medium based on arduino microcontroller. The design works with by exploiting fluorescence phenomenon, by using Purple Light Emitting Diode (λ = 405 nm, P = 10 mW, frequency modulation 625 Hz) as a light source absorbed by phytoplankton, mesuring vessel, optical filters, and photodiodes. Data obtained of the photodiode sensor is then conducted data acquisition by arduino, the quantitiy of phytoplankton concentration will be displayed on the lcd. From testing to Phytopathton for the concentration range it was found that for the concentration range 102 - 106 cells / ml obtained a consistent relationship the intensity of fluorescence with the increase in cell concentration. Gradients obtained for high range concentration with R^2 = 0.9632 lower than the low range concentration with R^2 = 0.9642.

1. Introduction

Indonesia is an archipelago country where the geographical area of 75% is the ocean, one of nature potential with various marine fauna such as fish, terumbu karang, zooplankton, phytoplankton and others. Phytoplankton or so-called microalgae has a major role for the balance and sustainability of marine and terrestrial biota ecosystems [1]. Fish life and a variety of marine living things are highly dependent on phytoplankton which is the beginning of the food chain [2]. Phytoplankton function as a carbon cycle globally that can regulate the earth's temperature and oxygen-producing. So we need an observation to know the amount of phytoplankton concentration in a water area. The size of the phytoplankton in micrometer units and having unique characteristics can only be seen using a microscope to identify and calculate the amount of concentration [3] so it takes expertise in the field of biology. For the purposes of the field on fish hatchery and phytoplankton culture required a measuring instrument that is easy to operate to measure the concentration of phytoplankton. In this study the method used to detect the presence of phytoplankton using optical methods as light media. Optical method has the effect of phenomenon of light interaction on phytoplakton particles causing phenomenon of reflection, absorption, scattering, refraction, diffraction, interference and disperse. The use of optical method is aimed at this research is to see the existence of phytoplankton by way of physical process of light. Usually to identify the presence of phytoplankton requires a high-resolution microscope and a UV-Vis current spectrophotometer. This tool can only be operated in laboratory labs and can not operate in real time, this tool also has an economical value is expensive. By using optical

* Corresponding author: gunady.haryanto@univpancasila.ac.id

method it can be designed a measuring instrument that can be used in real time, economical and easy to operate.

The basis of the optical measurement method utilizes the effects of light absorption on a particular region by phytoplankton. With this method the light source will be generated by laser diode with light dectektor (PIN photodiode). Interferometry method is used for optical set-up configuration in design in this research. Interferometry method is used for optical set-up configuration in design in this research. Fluorescence or phosphorescence absorption and emission is the natural and dominant process of light physics when phytoplankton responds to light. To measure the proposional level that occurs in the absorption of light technically will compare the presence of phytoplankton and its inability.

The main basis for selecting optical methods in the measurement of phytopathton concentrations is:

a. The optical measurement method is a method of measurement whose resolution is within the wavelength dimension of the micrometer-nanometer scale so that expected by the optical method used in this study can yield accurate measurement data in identifying the presence / types and quantities of phytoplankton species.
b. Optical method is a method that can be integrated with electronic systems so that the measurement in real time can be done without having to do chemical testing in the laboratory and signal processing can be done electronically and data processing can be integrated with computer in the form of software.
c. The optical method is an appropriate aplicative technology for designing phtyoplankton concentration measuring devices economically so that the success of the device design can be widely used by Indonesian fishermen and fish farmers.
d. The optical measurement method is an in-situ and non-destructive measurement method so that measurements can be made on-site and do not endanger the life cycle of phytoplankton.

The main issues that will be solved and analyzed related to the achievement of the objectives of this research are:

- The size of phytoplankton in the micrometer scale will be an obstacle for measuring instruments to be designed in terms of precision and accuracy so that it should be a primary consideration in the detection system.
- Different types and species of phytoplankton are serious problems to consider in this study because each phytoplankton has unique biological characteristics and varies according to its ecosystem.

The optical phenomenon used as a reference analysis is the phenomenon of absorbance and fluorescence of phytoplankton occurring in response to the light beam falling on the microbial creature, fluorescence emission characteristic of the phytoplankton as the determinant of the laser wavelength to be used as the primary detecting medium. So that the accuracy of the fluorescence fluorescence characteristic analysis will have a big effect on the accuracy of the measurement result.

The main objectives to be achieved in this research are:

- Designing sensors capable of accurately identifying the presence of phytoplankton according to the type of species desired.
- Designing precise and accurate quantity of phytoplankton devices in measurement resolution of 50 cells / ml.
- Designing phytoplankton detectors that have an in-situ, compact, non-destructive, user friendly and economical advantages.

- Designing microcontroller based phytoplankton measuring instrument as a data processing center.

2. Theory

2.1 Fluorescence Spectroscopy Study

Fluorescence is a photon emission process that occurs when the molecule is in a state of relaxation so that the conditions result in photon emission at a duration of approximately 10-9 s duration. The excitation process that occurs involves a single state process so that the lifetime of the upper state increases and ultimately leads to a transition to a metastable state. Quantum emissions in fluorescence depend on the degree of balance between radiative and non-radiative relaxation. While the intensity of light emitted from the process is to follow Lambert's law;

$$I = I_0 \exp(-\varepsilon c l) \quad (1)$$

where ε : absorption coefficient;c = medium concentration; l is the time of photon emission

3. Measurement Device Component

Measurements of the concentration of fitolankton dissolved in a liquid medium comprise a probe, signal processor, and driver circuit. The probe consists of a light source and detector an adjacent signal amplifier for maximum fluorescence intensity. The desired device is portable and easy to use in the field, therefore the probe is placed separately from the processor driver circuit. These three sections are connected with cables as shown in Figure 1 Probes can be immersed into a liquid medium and confronted in different directions or moved

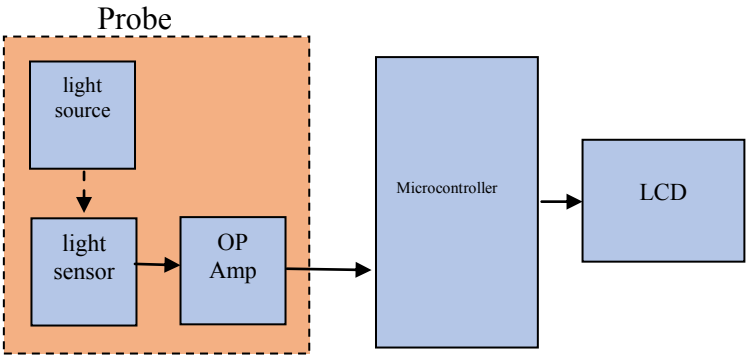

Fig. 1. Fitoplankton concentration gauge block diagram.

3.1 Light source

Based on the absorbance spectrum obtained from Phytoplankton test results. To be able to produce light that is able to excite the phytoplankton used a light source LED diode 405E (Thorlabs) can be seen in Figure 2.

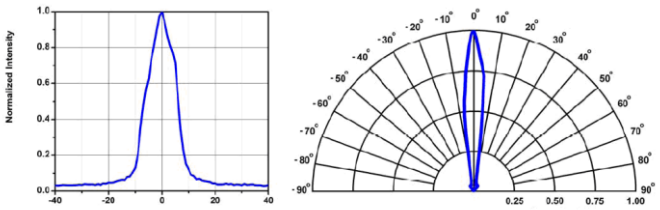

Fig. 2 The direction of the intensity distribution of LED405E Thorlabs

3.2 Photodioda Sensor

Based on the fluorescence characteristic of Phytoplankton obtained the dominant spectrum at 685 nm wavelength. To be able to detect the fluorescence produced by phytoplankton is used a photodiode. In this research the photodiode is used PIN type from Si type FDS100 made by Thorlabs. This photodiode has a spectrum response of 350 - 1100 nm and is used as a light detector worked in a conductive photo mode and coupled with an operational amplifier (Op - Amp).

3.3 Driver LED

In the measurement process, the photodiode functions to receive the fluorescent light due to the light coming from the LED. But in reality, there is light coming from other sources such as scattering. To solve this problem in the process of measurement, the light emitted by the LED must be differentiated and detected separately. Therefore a method is sed by laying the amplitude modulation signal on the light emitted by the LED

3.4 Analog Signal Boosters and Processors

Photodiode output signal is very small, ie in the order μV. Therefore it takes a signal amplifier circuit (pre-amplifier) to obtain a signal that can be easily processed further. An amplifier Operational Amplifier IC LM358 is selected for this purpose with the consideration that its characteristics meet the requirements.

3.5 Optical Filters

To avoid detecting light other than fluorescence light, optical filters are used only through the fluorescence light. The filter used is made of plastic with a spectral transmission response of 600 - 730 nm [17]. The installed filter r5 attaches to the photodiode surface and is protected by glass to avoid direct contact with the culture water.

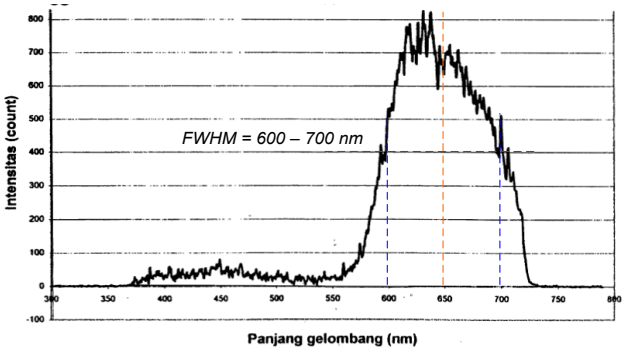

Fig. 3. Spectrum of optical filter used

3.6 Design and Manufacture of Optical Probes

By involving the previously described parts, the arrangement of the optical set up (probe). Before going to the LED light beam measuring container is focused by the lens d = 3 mm, f = 10 mm in the sleeve. The sleeve is made of plastic material and has a size adjusted to the diameter of the LED to excite the phytoplankton, while the photodiode is used to detect fluorescence intensity. In this voltage range, the light energy that can be used to excite is 0 - 20 mJ, while the modulation frequency generated by the LED Driver is 625 Hz. The fluorescence intensity detection result is then fed to the pre-amplifier and measured by Voltmeter.

3.7 Microcontroller

The microcontroller used as instrument control center is arduino uno which operates at 5V DC voltage. In the measurement instrument of phytoplankton concentration there are several ports used, including: digital port pin 2 as input data from light sensor of A5 digital port port. The main series of arduino uno can be seen in Figure 3.4

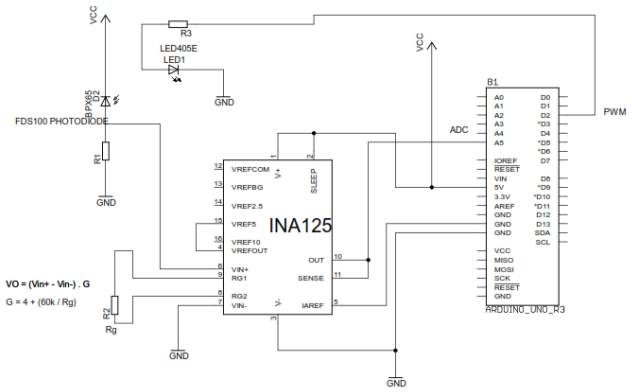

Fig. 4. microcontroller system design circuit

4. Measurement Results Concentration Scenedesmus sp.

Furthermore, the measurement results representing the intensity of the fluorescence and the intensity of light before penetrating the culture for each concentration (102 to 106 cells / ml) at room temperature 26 ° C is processed and presented in graphical form Figure 5.2 a and b. In the graph a results of Scenedesmus sp measurements of 102 up to 1 x 104 cells / ml and on the graph b of Scenedesmus sp measurements from 5x104 to 1 x 106 cells / ml.

From the measurement result of Figure 4.1 (a) the concentration of 102-104 cells / ml, it is known that the normalized intensity increases linearly along with the increase of Scenedesmus sp. The gradient in the range 102 to 104 cells / ml is 2 x 10-8 and the standard deviation value (R^2) is 0.9642. As for Fig. 5.2 (b) the gradient in the 5 x 104 - 106 cell / ml range is 1 x 10-9 and the standard deviation (R^2) is 0.9632.

These results show that for the high concentration range (5x104-106 cells / ml) the resulting curve gradient is relatively smaller compared to the low concentration range (102-199 cells / ml) due to the influence of reabsorption by phytoplankton.

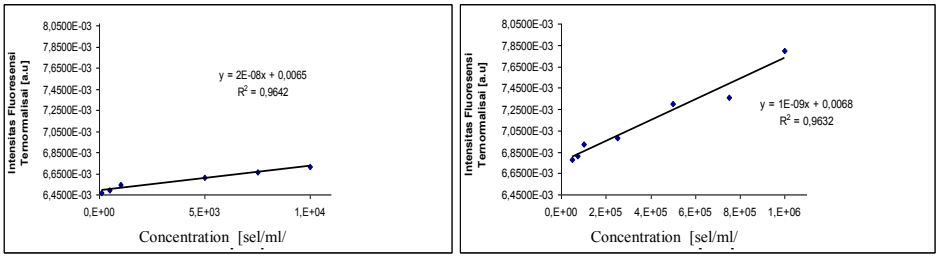

Fig. 5. Effect of Scenedesmus sp concentration on fluorescence intensity.
(a.) concentration 0 - 104 cells / ml
(b.) concentrations 5x 104 - 106 cells / ml

Can be seen from Figure 5. that the intensity of fluorescence increases with the increase in the consentration of Scenedesmus sp cells.

5. Conclusion

From the design results, the Phytoplankton test and measurement are:

1. Absorption of light by Phytoplaknton occurs at 400 - 500 nm spectral.
2. Phytoplankton has a typical fluorescence spectrum in which there is a large intensity fluctuation in the range 652 - 789 nm and its intensity peaks occur at 681nm, 752nm, and 777nm.
3. In order to produce accurate phytoplankton concentration value, an analog 10 to bit digital converter is required.

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