Digital Image Processing and Analysis System to Measure Microalgae Concentration for Biofuel Production

July 2020

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A Dissertation Submitted to
the Graduate School of Life and Environmental Sciences,
the University of Tsukuba
in Partial Fulfilment of the Requirements
for the Degree of Doctor of Philosophy in Agricultural Science
(Doctoral Program in Appropriate Technology and Sciences for Sustainable Development)

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Abstract

Microalgae have recently attracted considerable interest worldwide, due to their extensive application potential in the renewable energy, biopharmaceutical, and nutraceutical industries. Microalgae are renewable, sustainable, and economical sources of biofuels, bioactive medicinal products, and food ingredients. Several microalgae species have been investigated for their potential as value-added products with remarkable pharmacological and biological qualities. As biofuels, they are a perfect substitute for liquid fossil fuels with respect to cost, renewability, and environmental concerns. Although microalgae are feasible sources for bioenergy in general, some limitations and challenges remain, which must be overcome to upgrade the technology from pilot-phase to industrial level. Microalgae can be cultured by different methods and under different conditions. They need light as an energy source to convert the absorbed water and CO_2 into biomass through photosynthesis. The most challenging and crucial issues are to obtain the microalgae concentration in a short time, the possibility for a sustained monitoring system in real-time, and enhancing the microalgae growth rate. This study focuses on the use of digital image processing techniques to predict microalgae concentration values appropriately. This technique has many advantages compared to conventional methods, such as appropriate method for microalgae indoor and outdoor cultivation systems. For indoor systems, common microalgae cultivation uses the Photobioreactor (PBR) system, and for outdoor cultivation systems uses Open Raceway Pond (ORP). In general, to determine the microalgae concentration values using digital image processing techniques is relatively rare, as well as not widely used. Even though this technique should be effective and not destructive since the process has no direct contact with the microalgae. Therefore, this study focuses on the use of digital image processing techniques to predict microalgae concentration values appropriately. As it is known, digital image processing has the potential for estimating during cultivation of microalgae in Photobioreactor (PBR). In this research, computer algorithm and non-destructive method were implemented to predict the total concentrated solid of dry cell weight (DCW). This research used the native microalgae samples from the experimental facility located at the Minamisoma city of Fukushima Prefecture in Japan. Dry cell weight (DCW) were dissolved in a

predetermined concentration range up to 12 g DCW and proven to be efficiently used up to 3 g DCW. The digital image processing is based on a Red, Green, Blue (RGB) color. The RGB image analysis was applied to measure the concentration of native microalgae: *Desmodesmus* sp, *Scenedesmus* sp, *Dictyosphaerium* sp, and *Klebsormidium* sp. The experiments were performed by using different concentrations of dry cell weight (DCW) of these microalgae species. Raw Red, Green and Blue (*R*, *G*, *B*) values in microalgae were extracted and converted into Grayscale (GS) images. Furthermore, GS images were compared with seven conversion methods for determining the most suitable conversion results. The GS methods were investigated: Luminance, Intensity, Monotonic, Desaturation, Average, Minimum decomposition, and Lightness grayscale methods. The GS method was used to simplify the algorithm, for increasing efficiency in analyzing images. Each GS image of microalgae biomass aimed to derive a special pattern that only each image has in accordance with its concentration. For the result, Luminance GS was found the most suitable method for recognizing color pattern identifier to determine total solid concentration using the image taken from the mobile device (R^2 = 0.9033).

After ensuring the digital image processing with the Luminance method was suitable to predict microalgae concentration. Subsequently, the study was expanded by added a viscosity measurement method. Afterward, the Luminance and viscosity methods will be compared and analyzed, to determine the most efficient method for the microalgae concentration measurement. The aim of this study was to predict the concentration of microalgae using image processing and viscosity method. The experiments were performed by using different concentrations of dry cell weight (DCW) of these microalgae species. 1 g DCW was dissolved in a 500 mL volume of purified water. Subsequently, 0.01% - 0.20% of the DCW was placed in a container. A handy dual camera device was used to capture the image of the DCW solution in a flask, illuminated from the top. For viscosity, a viscometer was used in investigating the microalgae concentration. A comparative analysis was done between data from image processing and viscosity. The result of the image processing is the Luminance Grayscale (LGS) image. Further investigations revealed that the brightness of the DCW image has a limit at a certain concentration whereby the color is unrecognized. The current method of image processing has the potential to be applied in an outdoor cultivation facility for real-time data acquisition. The results from the viscosity

measurement method showed higher accuracy. Although the accuracy is higher, it requires a longer time to determine the concentration of the microalgae cultivation. Both methods have advantages in terms of required time and experimental costs. These provides alternative ways to efficiently monitor the cultivation and harvesting of microalgae.