MICROALGAE CULTIVATION IN LATVIAN CLIMATIC CONDITIONS

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Abstract. The paper describes an attempt to grow microalgae in outdoor raceway ponds. The most suitable microalgae species were determined for outdoor cultivation in Latvian climatic conditions. Indoor *Scenedesmus quadricauda* L. microalgae cultivation was done to provide enough microalgae for raceway pond start medium. A black plastic film was used to relay the raceway pond ground. Measurements of total dissolved solids in growth media were proceeded to determine the need for adding nutrients to the pond medium. The lowest stream speed was determined to avoid microalgae sedimentation during night time to save electricity. Every day temperature measurements in raceway pond show that microalgae cultivation during summer can be performed in Latvian climatic conditions.

Keywords: microalgae, raceway pond, biofuels, paddlewheel.

Introduction

The increase in the greenhouse effect, which is mainly caused by carbon dioxide (CO_2) is increasing the pressure to search for alternative biofuels, that could replace or at least reduce CO_2 pollution produced by vehicles. One of the ways is to replace fossil fuel with environmentally friendly biofuels. At the moment, one of the most common biofuel sources is rapeseed oil. However, the increasing demand for food makes scientists to seek for solutions how to more intensively use agricultural land as well as the opportunity to acquire non-agricultural land. This opportunity probably will be the cultivation of microalgae as a source of biofuel oil acquisition. At this moment, almost any farm that cultivates rapeseeds can produce rapeseed oil for their own use, but is it possible to successfully cultivate microalgae as easy as rapeseeds.

Materials and methods

To provide experimental outdoor cultivation in Latvian climatic conditions the most suitable microalgae specie was determined from the species that already live in the territory of Latvia. As the most promising candidate *Scenedesmus quadricauda* L. was chosen. *Scenedesmus quadricauda* L. is the most common microalgae in Latvian waters, with the lipid content 18 % from dry biomass, biomass productivity 0.19 $g\cdot(L\cdot day)^{-1}$ and lipid productivity 35 $mg\cdot(L\cdot day)^{-1}$ [1]. Pure culture multiplication was performed before experimental microalgae cultivation in outdoor conditions (Fig. 1).

Fig. 1. **Scenedesmus quadricauda cultivation**

Glass and plastic flasks and containers were used to multiply *Scenedesmus quadricauda* L. Multiplication proceeded indoors with temperature 24 ± 1 ºC, which is close to the optimal growth temperature for *Scenedesmus quadricauda* L. microalgae [2]. Start media for pure culture

Scenedesmus quadricauda L. multiplication was made according to the green algae growth standard "LVS EN ISO 8692". Media was made on distillated water base with adding the necessary amount of macro and micro nutrients. The lighting system needs to provide similar lightning conditions like in outdoor cultivation. To provide the light intensity similar to outdoor conditions "*Sera*" light bars were used. Artificial lightning provided 1.2 ± 0.2 klx light intensity and optimal red – blue color light for the photosynthesis process. By help of electrical timers a strict lightning cycle was maintained – 16 hours light cycle and 8 hours dark cycle similar to the outdoor light cycle during summer in Latvia [3]. The flasks and containers were closed and bubbled from the air compressor "*BOYU S – 1000A*" and "*RESUN AIR 4000*" prevented microalgae from sedimentation. The supplied air was filtered through a 1 µm filter to prevent other microalgae and predators from entering the growth media. Measurement of total dissolved solids in stock solution was made with *TDS – 3* meter (Fig. 2) and afterwards used to determinate when to add nutrients in the growth media.

Fig. 2. **Total dissolved solid meter *TDS – 3***

A raceway pond with a paddle wheel mixing system was built to provide outdoor cultivation (Fig. 3). The pond lope and inside wall were made from land embankments up to 0.65 m. The pond surface area 144 m^2, water level 0.35 m and value 50 m^3. A Black plastic film was used to relay the raceway pond to increase the water temperature.

The raceway pond was filled up with water from the nearby river filtrated through 1 µm filter to avoid from other microalgae species and possible predators. The cultivation media was prepared with nutrients and by adding 100 liters of high density microalgae substance.

Fig. 3. **Raceway pond with paddle wheel**

Microalgae mixing was provided by the paddle wheel with electrical motor controlled by a potentiometer and chain drive (Fig. 4). Dimensions of the paddle wheel – width 1.8 m and draft of paddles 0.15 m. The flow speed 0.25 m·s^{-1} was adjusted to prevent microalgae from sedimentation and provide similar light radiation for all cells [4]. Mixing during night time prevented microalgae from sedimentation and attaching to the plastic film. Attaching and sedimentation during night time was observed when mixing was provided only in day time.

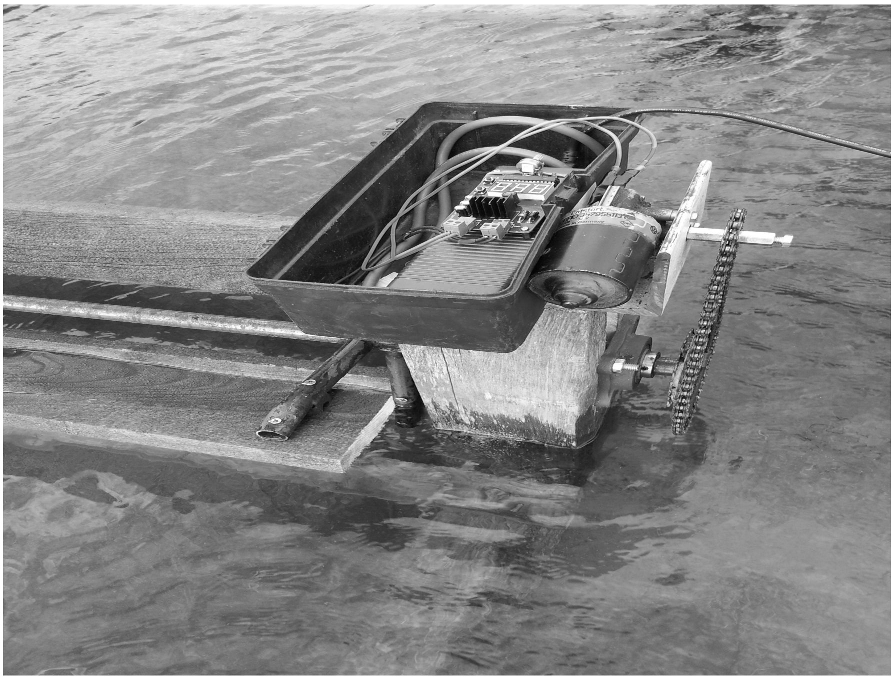

Fig. 4. **Drive mechanism with regulation potentiometer**

After determining the need for nutrients with total dissolved solid meter small amounts of complex fertilizer *Vito*, extra sodium nitrate ($NaNO_3$) and calcium chloride (CaCl) were added manually just before the paddle wheel to provide better nutrient dissolving in the growth media.

Results and discussion

This experiment was done to determine if microalgae cultivation can be done as easy as rapeseed cultivation for biofuel production. That is the reason why rather simple cultivation was hold on and measurements like microalgae cell duplication time and light radiation measurements were not measured. Experimental *Scenedesmus quadricauda* L. cultivation in the outdoor raceway pond was done in June, July and August. After introducing start media in the pond for the first weeks microalgae multiplication was not observed due to low water temperature (Fig. 5). As water temperature increased multiplication was observed as the media remained greener. Average raceway pond water temperature in June was 20.1 ºC that is 4 ºC below the optimal growth temperature for *Scenedesmus quadricauda* L. During June microalgae density in media rose, but it was too low for harvesting.

Several tests with higher mixing speeds were carried out to lift up most of microalgae. The test mixing with flow speed 1 $m \cdot s^{-1}$ was also unsuccessful. To prevent microalgae from sedimentation and attaching to the plastic film a number of tests with different flow speeds were carried out. The tested speeds were 0.05 $m \cdot s^{-1}$, 0.10 $m \cdot s^{-1}$, 0.15 $m \cdot s^{-1}$ and 0.20 $m \cdot s^{-1}$. The best results were observed by mixing with the flow speed 0.15 $m \cdot s^{-1}$ and 0.20 $m \cdot s^{-1}$. As the results were similar, the mixing flow speed with 0.15 $m \cdot s^{-1}$ was chosen to reduce the electricity costs.

From the end of June temperature started to raise gradually reaching the maximum temperature on the 11th of July with 26.6 ºC. This time period was with most significant increase in microalgae duplication. Nutrients were added on every second day, even with significant water evaporation. Water loss during evaporation was 0.5 cm day^{-1} in level, in volume it would be 720 liters. From the 7th till the 15th of July during evaporation the water level dropped down by 5 cm. To restore the water level, water was brought from the nearby river and filled without filtration.

After restoring the water level microalgae duplication stopped. At first it seemed that the temperature fall is the reason for it, but when temperature started to rise and it was in optimal boundaries from the 28th of July till the 7th of August and cell density also was not increasing some worries came over. Eventually, microalgae concentration started to reduce.

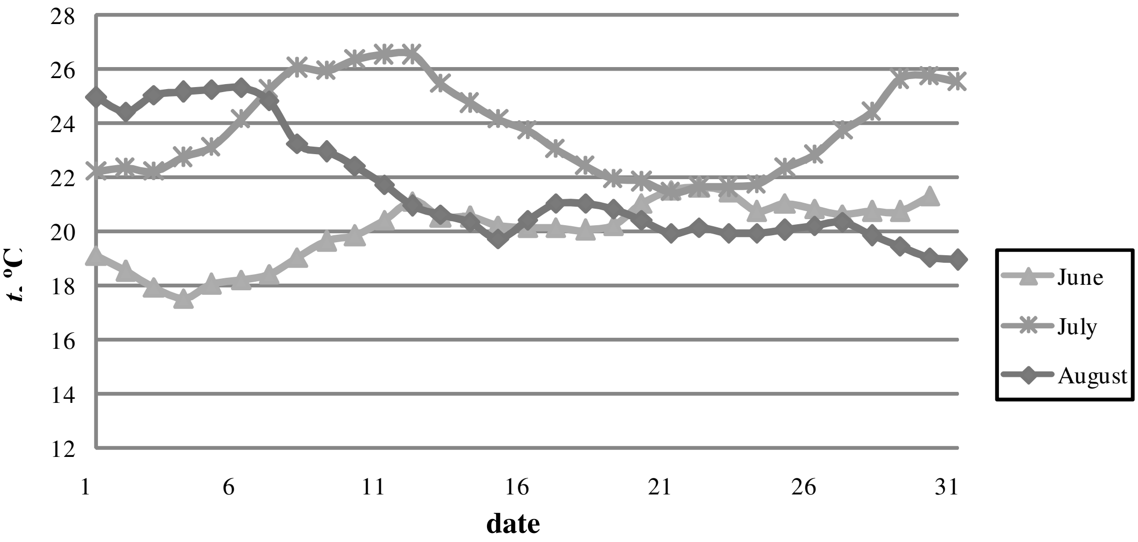

Fig. 5. **Raceway pond water temperature measurements in summer 2012**

Microalgae harvesting was done when the microalgae concentration started to reduce. The filtration method was used because the microalgae concentration was low. 1 μm filter was used for filtration. During filtration several filter elemets were changed because they clogged with paste of microalgae. Microalgae paste was collected from the filter element surface and sundried.

Conclusions

1. Mixing with the flow speed at 0.15 $m \cdot s^{-1}$ is the lowest speed that ensures microalgae from sedimentation during night time.
2. Raceway pond systems can be successfully used in Latvian climatic conditions.
3. Average water temperature in the raceway pond during summer was 22 ºC, which is suitable for successful microalgae cultivation.
4. There is a need to carry out research on microalgae predators like zooplankton and fungal, viral infections.

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