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Construction of a daylight-assisted algae-photobioreactor – First experiments

The use of renewable energies and the search for new sustainable sources of raw materials are worldwide in an even greater focus. Algae can be both source for regenerative energy recovery and are used as material. In the climate of central Europe, however it is problematic to grow algae all year-round. The light-assisted photobioreactor offers beside the advantage of a closed system, low external impacts and the easy manageability of the potential of an all year-round utilisation.

Keywords

Algae, photobioreactor, daylight system, micro algae, chlorella vulgaris, algae growth, algae breeding

Abstract

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Environmental pollution caused by climate change, rise in cost and scarcity of fuels, increasing cost of food, scarcity of food in different parts of earth as well as shortage of agricultural area are right now current news. They will be more problematic in near future and will lead to controversially discussions.

First steps to decrease climate change´s consequences are already done. At the moment the sector for bioenergy benefits by increasing employees, high finance investments, variety of new foundations and high earnings. Special emphases of science are discovering and implementation of new methods for increase of efficiency. In addition it is important to find organism which can be used as renewable resource in order to minimize the conflict between energy utilization and agricultural food production. Therefore algae are focused by science since a couple of years because of their manifold attributes. Many algae can be used for production of biodiesel, hydrogen and food right up to pharmaceutical products or biomass production, CO_2-reduction included. Nowadays these potentials are examined and partially applied with economic success. If there is a whole year round utilization possible algae could present wide variety of application possibilities caused by their varied properties

Assignment of tasks and assumption

For the substitution of fossil energy biomass and alternative resources must be found. Conditions for the usage of those alternatives are high growth rates and therefore a high amount of biomass. This is only ensured, if a year round production is possible. As a consequence it is obvious to develop a reactor which is adequate insulated to ensure a continuous production of biomass throughout the year. This insulation is responsible that light cannot get into the reactors on normal way to the algae – Permeation through transparent light permeably reactors are not possible in that case. Therefore a daylight system has to be used. With this system daylight can be inserted by fibre optics inside the reactors. Because of the optimal growth conditions high biomass yields are expected.

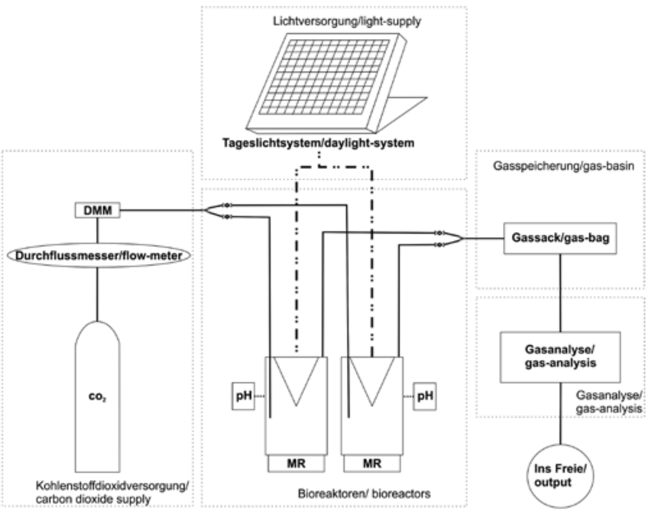
Methods

The daylight-assisted photobioreactor system can be structured in 5 main parts: 1 Supply of Carbone dioxide, 2. Light supply, 3 Bioreactors, 4. Gasbassin, 5. Gas analysis. Following components are used:

- Flask with pure CO_2
- Pressure reducer
- Magnetic stirrers
- Daylightsystem
- Gas analysis
- pH-Meter
- Pump
- Flow meter
- Gasbag

A flask filled with carbon dioxide is used for food supply for Chlorella vulgaris. Gas flows through both reactors and leads to the so called "airlift effect" – a vertical stirring of the algae emulsion. In addition magnetic stirrers are used to mix the mixture horizontally. The Daylight system provides light required for life to the algae. Permanent control of temperature and pH-meter guaranties an optimal observation of the perfect growing conditions. Non used gas or gas produced by the organisms is collected in gasbags and analysed by a gas analysis. At last the analysed gas is emitted to air. (**Figure 1**) During

Fig. 1



Model of the complete PBR-system, all components included

the first test the pH value and the temperature is measured all 60 minutes. At the same time during the filling of the gasbag with CO_2 measurements for CO_2 and O_2 concentration were collected every second, later on all 30 seconds. In addition the gas analysis recorded surrounding temperature and pressure.

Results

The Construction of the photobioreactor was constructed without any problems. After injection with *Chlorella vulgaris* algae growth was as expected. Due to regular measurements growth rate charts were constructed. Both growth rate charts of the bioreactors are shown in **Figure 2**. On the x-axis is the periods of time in day on the y-axis are the pH-value, temperature in Celsius degrees and the optical density of the Chlorella vulgaris algae solution. Both plotlines, growth rate 1 (algae growth in reactor 1) and growth rate 2 (algae growth rate in reactor 2) describe a similar increase in their growth gradient at the beginning. The optical density in the second reactor starts with 0,008 and increases till 19.09.2010 to its maximum value. The density in the first reactor starts with a lower value of 0,006. In the diagram you can see a continuous growth till 18.09.2010, followed by a little decline on the next day. Since 19.09.2010 there is high growth.

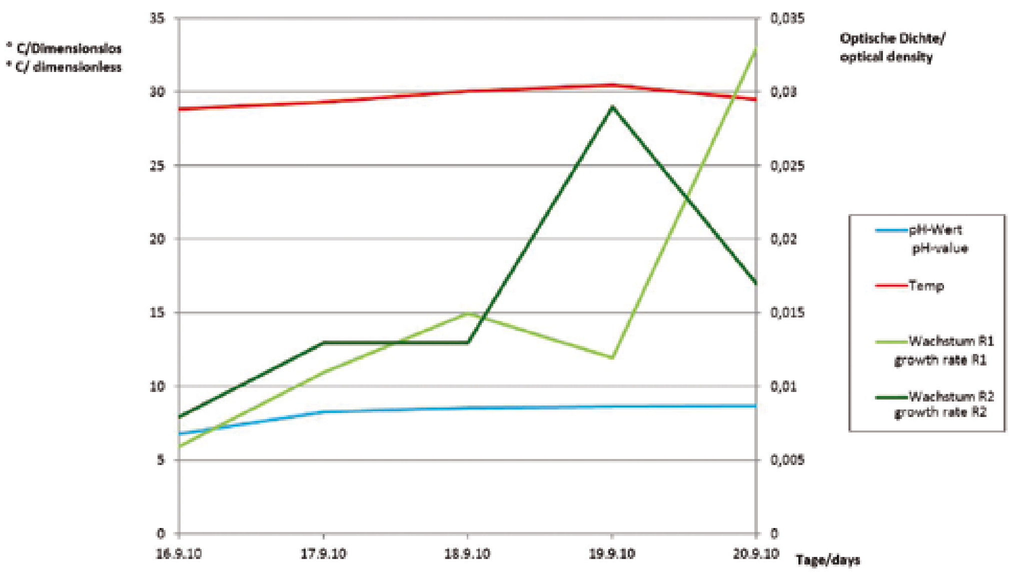
Discussion

Within the measurement period pH-value and temperature were able to be hold nearly constant. Bigger variability in temperature was prevented by an air conditioning unit. However the strong decrease of "growth rate R2" is conspicuous. First analysis shows that the magnetic stir bar pulverises the microorganisms on the stirring platform. A microscopic examination indicates bacterial contamination. Their concentration was non-hazardous for the algae. A water analysis shall provide information if there are toxic substances from the microorganisms.

Conclusion

This test setup shows that it is possible to construct a photobioreactor which is adequate insulated to produce continues biomass the whole year round. The insulation which is responsible for sunlight cannot be inserted to the algae on normal way. That means penetration of transparent, translucent reactors is not possible and therefore a daylight system has to be implemented. With more technical optimisations higher growth rates are possible and expected.

Fig. 2



Comparison of growth-rate of both reactors addicted to temperature pH-value in an time period of four days

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