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Technological and Construction Concept Algae Reactor with Internal CO_2 Supply

Hubert Kowalski* and Mirosław Krzemieniewski

Department of Environmental Engineering, University of Warmia and Mazury in Olsztyn, Poland

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***Corresponding author:** Hubert Kowalski, Department of Environmental Engineering, University of Warmia and Mazury in Olsztyn, Poland

Abstract

Human activity has a huge impact on the natural environment on our Earth. In particular, the combustion of fossil fuels supplies huge quantities of greenhouse gases and dust to the atmosphere. The substances contained in the gases contribute to the increase of the air temperature. Soil moisture is also reduced in very large areas. Many million people feel the effects of these phenomena. Therefore, it is necessary to undertake activities which will create better, safer living conditions in many regions of the world. For this purpose, it was constructed NLC - The New Life Capsule. NLC is a biological reactor whose idea is to create the right conditions for living together for algae and fungi. The reactor model was used in laboratory tests. It has been shown that conditions can be created for the development of algae and fungi. The article also presents the idea of an installation that in the future may work with NLC on a technical scale.

Keywords: Algae; Fungi; Carbon Dioxide; Sand Deserts; Plant Cultivation

Introduction

How is the New Life Capsule NLC constructed and how does it work?

The New Life Capsule NLC is a biological reactor whose idea is to create the right conditions for living together for algae and fungi. The algae would provide fungi with oxygen, and they would themselves take in the carbon dioxide necessary in the process of photosynthesis. The device has an advantage over the biological reactors used so far, because the influence of unfavorable weather conditions on the functioning of the biological reactor is significant.

The New Life Capsule NLC has two most important structural elements. These are: the algal reactor A and the fungi reactor B. Algae develop in the upper reactor A. They need water and a mineral nutrient. Water appears in the condensed water station [1] as a result of changes in the temperature of the air heated during the day and cooled down during the night. Water flows by gravity to the mixing tank [2], in which there is a mineral medium in the form of aggregate. During the contact of water with mineral aggregate water is enriched with mineral compounds necessary for development of algae. Reactor A is illuminated by light, which is supplied from a light generator [3]. Carbon dioxide CO_2 needed for algae, is produced in reactor B. The CO_2 gas is pumped [4] to the reactor A, where the carbon dioxide CO_2 is consumed by algae. Oxygen produced by algae is supplied to reactor B to provide aerobic conditions in the mycelium. On the outflow from reactor B there is a substrate [5], which is a mixture of undigested algae, fungal biomass and other substances like organic and mineral compounds. This substrate [5], as a valuable fertilizer, is pumped into drainage [6], from which it flows down to the lower layers of soil [7]. In the soil [7], a new bacterial flora and other organisms are developed, and in this way very good conditions are created to enable cultivation of plants [8].

Research on a Laboratory Scale

Model of NLC

The main element is a transparent plastic pipe with a length of 500mm and a diameter 250mm. It is closed by the upper and bottom plastic covers. The algae reactor along its length is filled with 20 shelves. They are made from transparent polycarbonate with a thickness 1.0mm. In each shelf there is an overflow connector with a diameter 10mm and a length of 15mm. On the wall of the algae reactor there are 20 inspection holes with a diameter of 10mm. The 6W light generator is a light wire with LEDs with a diameter of 12mm, operating continuously (Figure 1).

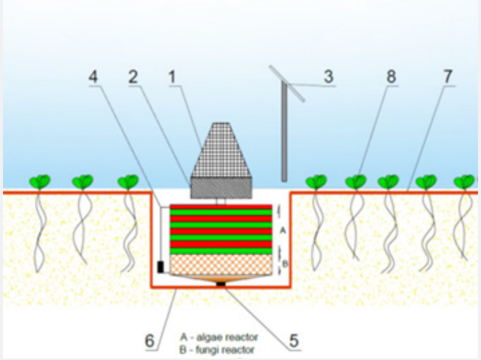

Figure 1: NLC technological and construction concept [source: own studies]

In the upper plastic cover of the reactor there is a 10mm diameter and 30mm long connector, which is used to periodically introduce the medium and to extract the air from the reactor, as well as to introduce the air from the fungi reactor (it is connected to the recirculation air pump). The other 8mm diameter connector is connected to the recirculating water pump. The bottom cover also has two connectors with a diameter of 10mm. The one is connected to the fungi reactor and the other with a diameter of 8mm with a recirculation pump. The recirculation pump is periodically pumped algae biomass from the last bottom shelf to the highest.

The fungi reactor is located under an algae reactor. The main element is a transparent plastic pipe with a length of 300mm and a diameter of 250mm. It is also closed by the upper and bottom plastic covers. The upper plastic cover has a 10mm diameter connector which is connected to the algae reactor. In the bottom plastic covers there is a 10mm diameter connector which is connected to the fan. The fan (1,8W, capacity of 0.020 m3/h) operating continuously. The air from the top shelf of the algae reactor was pumped to the last bottom shelf of the fungi reactor (Figure 2). The second connector is for periodic drainage of leachate. The fungi reactor along its length is filled with 6 shelves which are made from transparent polycarbonate with a thickness 1.0mm. On the surface of each shelf is placed a perforated grid, on which there is biomass with fungi. In each shelf there is an overflow connector with a diameter 10mm and a length 5mm and a ventilation connector with a diameter of 20mm and a height of 30mm. On the wall of the fungi reactor there are 6 inspection holes with a diameter of 30mm.

Figure 2: Laboratory scale reactor [source: own studies]

Both algae and fungi reactors are located in a special cabinet. It has a rectangular shape with dimensions of 500mm x 800mm and a height of 1200mm. The material is a thin steel sheet 1.0mm thick. Inside, the cabinet is covered with 20-30 mm thick insulation material. Inside the cabinet there is a heating cable with a resistance value of 2.5 Ω/m, wire diameter 0.5mm, with a controller to maintain the temperature inside the enclosure at 35°C.

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Technological start-up procedure of the algae and fungi reactor

During the technological start-up of the algae reactor, the fungi reactor was turned off. The algae reactor was filled with algae biomass from a similarly constructed reactor. 500ml of medium was dosed once a week through the connector. Its composition was determined for Chlorella vulgaris. The volume of 500ml of medium was dosed once a week through the connector. Air with pure CO_2 was pumped to the last bottom shelf so that the dosing air contained about 14% CO_2. The amount of air was constant 24 dcm3 / d. After 12 days, the CO_2 share in the air leaving the reactor was stable at around 0.4%. At the same time, biomass with fungi was prepared in the extern reactor (Figure 3). The reactor was fed with algae concentrated from its own culture in open reactors with a capacity of 1.0 m3. The biomass structure consisted of compost biomass from own farm, Common Reed, Miscantus, deciduous sawdust (birch). The biomass was prepared within 1 month. After this time, the prepared biomass with algae, which constituted 0.3 of the total volume, was mixed with a new portion of the biomass - Common cane, Miscantus, sawdust from deciduous tree (birch). The biomass prepared in this way was introduced into the laboratory fungi reactor.

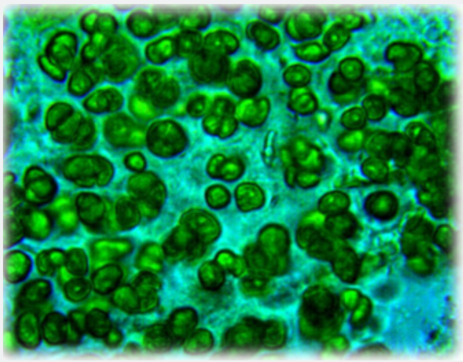

Figure 3: Microscopic analysis of algae [source: own studies].

Results

The research was conducted for 3 months. Still, 500 ml of medium was introduced into the algae reactor once a week and after a day a similar amount of effluent was drained from the fungi reactor. The percentage of oxygen and carbon dioxide at the outflow from the algae reactor before delivery to the fungi reactor was very stable and throughout the entire study period was as follows: 20.30% O2 and 0.40% CO_2. On the other hand, the quality of the leachate was as follows: COD 440-500 mgO2/dcm3, Total nitrogen 30-50mgNt/dcm3, total phosphorus 18-30mgPt/dcm3. Algae microscopic tests were performed periodically. Their composition did not change during the experiment (Figure 4). The structure of algae biomass was also periodically examined. It has been shown that the shelf contains dry matter in biomass content of 40-50%, and on the last group the shelf contains dry matter in biomass contains 30-35%.

Figure 4: Dry mass after drying [source: own studies].

Summary

Research on algae and cyanobacteria is conducted in many directions Berner et al. [2] Daliry S. et al. [3]. It is dictated by various ways of using algae for health purposes, such as cosmetics, diet, for use as an alternative biofuel and also in the production of fertilizers. An important element is the development of algae

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in terms of growth rate, maintenance of homogeneous species of biomass, and especially important is the attention to such properties as the accumulation of storage substances Schnurr P et al. [7] Kazamia E et al. [6]. Genin S.N. et al. [5] Dvortesky D et al. [4]. The production of biofuels from algae biomass is not the only benefit resulting from their use. Algae could also be used to reduce carbon dioxide emissions to the atmosphere Adeniyi O.M. et al. [1]. However, the proposed reactor design creates new possibilities for the use of algae. They can restore biological life and then contribute to the creation of conditions for the development of agriculture in desert areas. Desert areas are characterized by a negligible amount of precipitation and the occurrence of high air temperatures Wyngard S R, Kissinger M [8]. Due to such adverse weather conditions, evaporation significantly exceeds the amount of rainfall, which makes the vegetation cover in the desert's poor. Deserts are characterized by a constant humidity deficit, strong sunlight and significant temperature amplitudes. The device has an advantage over the biological reactors used so far, because the influence of unfavorable weather conditions on the functioning of the biological reactor is significant.

Research on a laboratory scale confirmed the validity of the adopted constructional and technological assumptions. However, construction of installations on a technical scale requires knowledge of the properties of the area where the installation is to be built. However, using the wrong methods can worsen the state of the natural environment. For example, supplying water to degraded arid land does not help, it only further aggravates soil degradation. This is because the water in the dry zone evaporates very quickly, leaving the salt that is dissolved in it. The salt is not leached into the soil, but it remains on its surface, quickly making it a completely barren field.

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