# C5/4 A TWO-PLANE TUBULAR PHOTOBIOREACTOR FOR OUTDOOR CULTURE OF SPIRULINA: DESIGN AND PERFORMANCE

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A photobioreactor in the form of a 245 m long loop made of plexiglass tubes having an i.d. of 2.6 cm was designed and constructed for outdoor culture of Spirulina. The loop was arranged in two planes, with fifteen 8 m long tubes in each plane. In the upper plane, the tubes were placed in the vacant space between the ones of the lower plane. In this way the two planes received all the incident radiation falling on the face of the photobioreactor. Such a design was developed in order to maximize capture of the radiation incident on the plane of the photobioreactor and to achieve full utilization of the land area it occupied. This second aspect could be important in developing tubular photobioreactors in areas where the price of land is high. The culture recycle was performed with two air-lifts, one per plane. The culture flowed from one plane to the other so that the two planes formed a single loop. Another important aspect of the photobioreactor design was the use of two air-lifts for the culture recycle in the photobioreactor. In this way, both mixing of the culture and the oxygen degassing were greatly facilitated. The power required for water recycle in the tubular photobioreactor with Reynolds number of 4000 was $3.93 \times 10^{-2}$ W $m^{-2}$. The photobioreactor contained 145 L of culture and covered an overall area of 7.8 $m^2$. The photobioreactor operation was computer controlled. Viscosity measurements performed on Spirulina cultures having different biomass concentrations showed non-Newtonian behaviour displaying decreasing viscosity with an increasing shear rate. The performance of the two-plane photobioreactor was tested under the climatic conditions of central Italy (latitude 43.8° N, longitude 11.3° E). During the month of July, which corresponds to the maximum monthly solar radiation (mean 25.5 MJ $m^{-2}$ $d^{-1}$), the productivity relative to daylight period reached a mean value of 33.4 g $m^{-2}$ $d^{-1}$ in the culture which was operated at a biomass concentration of about 3.5 g $L^{-1}$. Because of night biomass loss, net productivity (i.e. productivity over 24 h) descended to 27.8 g $m^{-2}$ $d^{-1}$. Night biomass loss in this culture accounted for 16.7% of daylight productivity and 5.7% of the total biomass load reached in the evening. When the biomass concentration was increased to 6.24 g $L^{-1}$ both daylight and net productivities decreased to 30.9 and 24.2 g $m^{-2}$ $d^{-1}$ respectively. In that culture, the average night biomass loss amounted to 21.7% of daylight productivity.

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