Abstract
The indices for assessing the efficiency of photobioreactors include (a) solar light interception per unit land area, (b) uniform distribution of light among the cells (through spatial distribution of light inside the ptotobioreactor and circulatory movement of the cells). (c) mass transfer capacity (adequate supply of carbon dioxide and removal of photosynthetically generated oxygen with minimal hydrodynamic stress on the cell); (d) ability to maintain sterile condition; (e) ability to control the culture conditions; (f) ability to scale up to industrial size; and (g) cost effectiveness. The requirement and optimal value for each of the above indices depend on the strain, the product and the location. Therefore, there is no best photobioreactor for cultivation of all types of cells at any location. In other words, design and construction of any photobioreactor have to be based on the physiology and growth characteristics of the strains, the target product and the geographical location. From the technological point of view, for a given cell strains and location, a photobioreactor that satisfy points (a) to (f) can be constructed. However, use of such photobioreactor for industrial production if often prevented by costs. It is obvious that for many cell strains and geographical locations, flat plate and tubular photobioreactor can satisfy these conditions better than do open cultivation ponds. However, it is unlikely that flat plate or tubular photobioreactors will replace open ponds for cultivation of Spirulina Dunaliella or Chlorella species in the near future. Nevertheless, these photobioreactors have great potentials for cultivation of some species which cannot be cultivated (or grow very poorly) in open ponds. At least with the most of the pilot to large scale flat plate and tubular photobioreactors reported so far, it would be difficult to maintain complete sterile conditions, and control the culture conditions (temperature, pH etc.) at their optimum values. Thus, their industrial application would be again limited to some strains that do not require strict sterile conditions and control of culture conditions. An industrial scale internally illuminated photobioreactor with optimal culture conditions (light regime, mass transfer capacity, sterility, process, control, etc.) can be designed and constructed for any cultivable microalga. Although the current costs of such photobioreactors are still too high for commercial photoautotrophic cultivations of most microalgae. It expected that in the future, the cost of light collection and distribution inside photobioreactors will substancially decrease, making it economical to use them for cultivation of various strains of microalgae. They are the “future ideal photoautotrophic photobioreactors.” Presently, there is great potential for processes incorporating heterotrophic metabolism such as in photohetertrophic cultures, sequential photoheterotrophic photoautotrophic cultures and cyclic heterotrophic photoautotrophic cultures. Depending on the microalgae strain, the increase in the productivity (which can be more than one order of magnitude higher) may justify the increased investment costs. However, more detailed studies on process optimization with various photosynthetic cells are required on a case by case basis.