

[Home](#) > [Journal](#) > [Earth & Environmental Sciences](#) > [JEP](#)
[Indexing](#) | [View Papers](#) | [Aims & Scope](#) | [Editorial Board](#) | [Guideline](#) | [Article Processing Charges](#)
[JEP](#) > Vol.2 No.5, July 2011



Microalgae Tolerance to High Concentrations of Carbon Dioxide: A Review

PDF (Size: 158KB) PP. 648-654 DOI : 10.4236/jep.2011.25074

Author(s)

Fadhil M. Salih

ABSTRACT

The increasing concentration of carbon dioxide (CO₂) in the atmosphere is considered to be one of the main causes of the global warming problem. Moreover, there is an international movement to reduce the emission of CO₂ by imposing different measures such as carbon tax. Biological CO₂ fixation has been extensively investigated as part of efforts to solve the global warming problem. Microalgae are fast growing systems that can consume high quantities of CO₂ to produce different types of biomass. The efficiency of microalgae is highly related to the concentration of CO₂ in the growth atmosphere and the higher the concentration of CO₂ the better is the growth and hence productivity. The present review aimed at shedding some light upon microalgal capability to sustain their viability and propagate under high CO₂ concentration.

KEYWORDS

Carbon Dioxide, Microalgae, Tolerance, Sequestration

Cite this paper

F. Salih, "Microalgae Tolerance to High Concentrations of Carbon Dioxide: A Review," *Journal of Environmental Protection*, Vol. 2 No. 5, 2011, pp. 648-654. doi: 10.4236/jep.2011.25074.

References

- [1] D. J. Stepan, R. E. Shockey, T. A. Moe and R. Dorn. " SUBTASK, 2.3-Carbon Dioxide Sequestering Using Microalgal Systems," U.S. Department of Energy, National Energy Technology Laboratory, 2001.
- [2] B. Hileman, " U.S. Urged to Change CO2 Emissions Policy," Chemical Engineering News, Vol. 70, No. 1, 1992, pp. 16-22. doi:10.1021/cen-v070n008.p016
- [3] O. Pulz and W. Gross, " Valuable Products from Biotechnology of Microalgae," Applied Microbiology and Biotechnology, Vol. 65, No. 3, 2004, pp. 635-648. doi: 10.1007/s00253-004-1647-x
- [4] Y. Chisti, " Biodiesel from Microalgae," Biotechnology Advances, Vol. 25, No. 3, 2007, pp. 294-306. doi: 10.1016/j.biotechadv.2007.02.001
- [5] E. Ono and J. L. Cuello, " Selection of Optimal Microalgae Species for CO2 Sequestration," Proceedings 2nd Annual Conference on Carbon Sequestration, Alexandria, 2003, pp. 1-7.
- [6] Oilgae, " Algae Oil Yield," 2011. <http://www.oilgae.com/algae/oil/yield/yield.html>
- [7] Biofpr, " The Promise and Challenges of Microalgal-Derived Biofuels," 2009. http://www.afdc.energy.gov/afdc/pdfs/microalgal_biofuels_darzens.pdf
- [8] J. H. Fike, D. J. Parrish, J. Alwang and J. S. Cundiff, " Challenges for Deploying Dedicated, Large-Scale, Bioenergy Systems in the USA," Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, Vol. 2, No. 64, 2007, pp. 1-28.
- [9] P. Chelf, L. M. Brown and C. E. Wyman, " Aquatic Biomass Resources and Carbon Dioxide," Biomass and Bioenergy, Vol. 4, No. 3, 1993, pp. 175-183. doi: 10.1016/0961-9534(93)90057-B

- [Open Special Issues](#)
- [Published Special Issues](#)
- [Special Issues Guideline](#)

[JEP Subscription](#)
[Most popular papers in JEP](#)
[About JEP News](#)
[Frequently Asked Questions](#)
[Recommend to Peers](#)
[Recommend to Library](#)
[Contact Us](#)

Downloads:	301,500
Visits:	673,226

Sponsors, Associates, and Links >>

- [The International Conference on Pollution and Treatment Technology \(PTT 2013\)](#)

- [10] K. L. Kada, " Microalgae Production from Power Plant Flue Gas: Environmental Implications on a Life Cycle Basis," National Renewable Energy Laboratory publications, NREL/TP-510-29417, Golden, CO, 2001. doi:10.2172/783405
- [11] J. R. Beneman, D. M. Tillett and J. C. Weissman, " Microalgae Biotechnology," Trends in Biotechnology, Vol. 5, No. 2, 1987, pp.47-53.
- [12] E. S. Kikkinides, R. T. Yang and S. H. Cho, " Concentration and recovery of carbon dioxide from flue gas by pressure swing adsorption," Industrial Engineering Chemistry Research, Vol. 32, No. 11, 1993, pp. 2714-2720. doi:10.1021/ie00023a038
- [13] D. Kilowatts, " America' s Most Polluting Power Plants," Environmental, Integrity Project, National Renewable Energy Laboratory Publications, Washington DC, July 2007.
- [14] J. Seckbach, H. Gross and M. B. Nathan, " Growth and Photosynthesis of Cyanidium Caldarium Cultured under Pure CO₂," Israel Journal of Botany, Vol. 20, 1971, pp. 84-90,
- [15] N. Hanagata, T. Takeuchi and Y. Fukujū, " Tolerance of Microalgae to High CO₂ and High Temperature," Phytochemistry, Vol. 31, No. 10, 1992, pp. 3345-3348. doi:10.1016/0031-9422(92)83682-O
- [16] M. Kodama, H. Ikemoto and S. Miyachi, " A New Species of Highly CO₂-Tolreant Fast-Growing Marine Microalga Suitable for High-Density Culture," Journal of Marine Biotechnology, Vol. 1, No. 1, 1993, pp. 21-25.
- [17] S. Miyairi, " CO₂ Assimilation in a Thermophilic Cyanobacterium," Energy Conversion and Management, Vol. 36, No. 6-9, 1995, pp. 763-766. doi:10.1016/0196-8904(95)00116-U
- [18] Y. Nakano, K. Miyatake, H. Okuno, K. Hamazaki, S. Takenaka, N. Honami, M. Kiyota, I. Aiga and J. Kondo, " Growth of Photosynthetic Algae Euglena in High CO₂ Conditions and Its Photosynthetic Characteristics," Acta Horticulturae, Vol. 440, No. 9, 1996, pp. 49-54.
- [19] H. Nagase, K. Eguchi, K. Yoshihara, K. Hirata and K. Miyamoto, " Improvement of Microalgal NO_x Removal in Bubble Column and Airlift Reactors," Journal of Fermentation and Bioengineering, Vol. 86, No. 4, 1998, pp. 421-423. doi:10.1016/S0922-338X(99)89018-7
- [20] K. Yoshihara, H. Nagase, K. Eguchi, K. Hirata and K. Miyamoto, " Biological Elimination of Nitric Oxide and Carbon Dioxide from Flue Gas by Marine Microalga NOA-113 Cultivation in a Long Tubular Photobioreactor," Journal of Fermentation and Bioengineering, Vol. 82, No. 4, 1996, pp. 351-354. doi:10.1016/0922-338X(96)89149-5
- [21] Y. Miura, W. Yamada, K. Hirata, K., Miyamoto and M. Kiyohara, " Stimulation of Hydrogen Production in Algal Cells Grown under High CO₂ Concentration and Low Temperature," Applied Biochemistry and Biotechnology, Vol. 39-40, No. 1, 1993, pp. 753-761. doi:10.1007/BF02919033
- [22] H. Matsumoto, N. Shioji, A. Hamasaki, Y. Ikuta, Y. Fukuda, M. Sato, N. Endo and T. Tsukamoto, " Carbon Dioxide Fixation by Microalgae Photosynthesis Using Actual Flue Gas Discharged from a Boiler," Applied Biochemistry and Biotechnology, Vol. 51-52, No. 1, 1995, 681-692. doi:10.1007/BF02933469
- [23] S. Hirata, M. Hayashitani, M. Taya and S. Tone, " Carbon Dioxide Fixation in Batch Culture of Chlorella sp. Using a Photobioreactor with a Sunlight-Collection Device," Journal of fermentation and bioengineering, Vol. 81, No. 5, 1996, pp. 470-472. doi:10.1016/0922-338X(96)85151-8
- [24] S. Hirata, M. Taya and S. Tone, " Characterization of Chlorella Cell Cultures in Batch and Continuous Operations under a Photoautotrophic Condition," Journal of Chemical Engineering of Japan, Vol. 29, No. 6, 1996, pp. 953-959. doi:10.1252/jcej.29.953
- [25] K. Maeda, M. Owada, N. Kimura, L. Omata, and I. Karube, " CO₂ Fixation from the Flue Gas on Coal-fired Thermal Power Plant by Microalgae," Energy conversion Management, Vol. 36, No. 6-9, 1995, pp. 717-720. doi:10.1016/0196-8904(95)00105-M
- [26] L. E. Graham and L. W. Wilcox, " Algae," Prentice-Hall, Inc., Upper Saddle River, 2000.
- [27] L. M. Brown, " Uptake of Carbon Dioxide from Flue Gas by Microalgae," Energy Conversion and Management, Vol. 37, No. 6-8, 1996, pp. 1363-1367.
- [28] T. M. Sobczuk, F. G. Camacho, F. C. Rubio, F. G. A. Fernandez and E. M. Grima, " Carbon Dioxide Uptake Efficiency by Outdoor Microalgal Cultures in Tubular Airlift Photobioreactors," Biotechnology

- [29] J. A. Oswald, " Large-Scale Algal Culture Systems (Engineering Aspects)," In: L. J. Borowitzka and M. A. Borowitzka, Eds., *Microalgal biotechnology*, Cambridge University Press, Cambridge, 1988, pp. 357-395.
- [30] P. Tapie and A. Bernard, " Microalgae Production Technical and Economic Evaluations," *Biotechnology and Bioengineering*, Vol. 32, No. 7, 1988, pp. 873-885. doi:10.1002/bit.260320705
- [31] S. Rados, B. Vaclav and D. Frantisek D, " CO2 Balance in Industrial Cultivation of Algae," *Archives of Hydrobiology*, Vol. 46, No. 12, 1975, pp. 297-310.
- [32] Y. K. Lee and H. K. Hing, " Supplying CO2 to Photosynthetic Algal Cultures by Diffusion through Gas-Permeable Membranes," *Applied Microbiology and Biotechnology*, Vol. 31, No. 3, 1989, pp.298-301. doi:10.1007/BF00258413
- [33] J. Beardall, S. Beer and J. A. Raven, " Biodiversity of Marine Plants in an Era of Climate Change: Some Predictions Based on Physiological Performance," *Botanica Marina*, Vol. 41, No. 1-6, 1998, pp. 113-124.
- [34] P. Schippers, M. Lüring and M. Scheffer, " Increase of Atmospheric CO2 Promotes Phytoplankton Productivity," *Ecology Letters*, Vol. 7, No. 6, 2004, pp. 446-451. doi:10.1111/j.1461-0248.2004.00597.x
- [35] J. K. Ward and B. R. Strain, " Elevated CO2 Studies: Past, Present and Future," *Tree Physiology*, Vol. 19, 1999, pp. 211-220.
- [36] S. Beer and E. Koch, " Photosynthesis of Marine Microalgae and Seagrasses in Globally Changing CO2 Environments," *Marine Ecology Progress Series*, Vol. 141, 1996, pp. 199-204. doi:10.3354/meps141199
- [37] J. Flexas, M. Ribas-Carbó, A. Diaz-Espejo, J. Galmés and H. Medrano, " Mesophyll Conductance to CO2: Current Knowledge and Future Prospects," *Plant, Cell and Environment*, Vol. 31, No. 5, 2008, pp. 602-621. doi:10.1111/j.1365-3040.2007.01757.x
- [38] T. Andersen, F. O. Andersen and O. Pedersen, " Increased CO2 in the Water around *Littorella Uniflora* Raises the Sediment O2 Concentration," *Aquatic Botany*, Vol. 84, No. 4, 2006, pp. 294-300. doi:10.1016/j.aquabot.2005.11.006
- [39] T. Andersen and F. O. Andersen, " Effects of CO2 Concentration on Growth of Filamentous Algae and *Littorella Uniflora* in a Danish Softwater Lake," *Aquatic Botany*, Vol. 84, No. 3, 2006, pp. 267-271. doi:10.1016/j.aquabot.2005.09.009
- [40] J. E. Kubler, A. M. Johnston and J. A. Raven, " The Effects of Reduced and Elevated CO2 and O2 on the Seaweed *Lomentaria Articulate*," *Plant, Cell and Environment*, Vol. 22, No. 10, 1999, pp. 1303-1310. doi:10.1046/j.1365-3040.1999.00492.x
- [41] B. Tisserat, " Influence of Ultra-High Carbon Dioxide Concentrations on Growth and Morphogenesis of Lamiaceae Species in Soil," *Journal of Herbs, Spices & Medicinal Plants*, Vol. 9, No. 1, 2002, pp. 81-89. doi:10.1300/J044v09n01_09
- [42] Y-S. Yun and J. Moon Park, " Development of Gas Recycling Photobioreactor System for Microalgal Carbon Dioxide Fixation," *Journal Korean Journal of Chemical Engineering*, Vol. 14, No. 4, 1997, pp. 297-300. doi:10.1007/BF02706827
- [43] L. Yue and W. Chen, " Isolation and Determination of Cultural Characteristics of a New Highly CO2 Tolerant Fresh Water Microalgae," *Energy Conversion and Management*, Vol. 46, No. 11-12, 2005, pp. 1868-1876. doi:10.1016/j.enconman.2004.10.010
- [44] Y. Watanabe, N. Ohmura and H. Saiki, " Isolation and Determination of Cultural Characteristics of Microalgae Which Functions under CO2 Enriched Atmosphere," *Energy Conversion and Management*, Vol. 33, No. 5-8, 1992, pp. 545-552. doi:10.1016/0196-8904(92)90054-Z
- [45] Y. Nakano, K. Hamasaki, S. Takenaka, K. Miyatake, A. Tani and I. Aiga, " Adaptation and the Mechanism of *Euglena gracilis* to High CO2 Conditions," *CELSS Journal*, Vol. 8, No. 2, 1995, pp. 7-12.
- [46] Y. Yang and K. Gao, " Effects of CO2 Concentrations on the Freshwater Microalgae, *Chlamydomonas Reinhardtii*, *Chlorella Pyrenoidosa* and *Scenedesmus Obliquus* (Chlorophyta)," *Journal of Applied Phycology*, Vol. 15, No. 5, 2003 , pp. 379-389. doi:10.1023/A:1026021021774

- [47] A. Papazia, P. Makridisb, P. Divanachb and K. Kotzabasisa, " Bioenergetic Changes in the Microalgal Photosynthetic Apparatus by Extremely High CO₂ Concentrations Induce an Intense Biomass Production," *Physiologia Plantarum*, Vol. 132, No. 3, 2008, pp. 338-349. doi:10.1111/j.1399-3054.2007.01015.x
- [48] T. Shiraiwa, " Mechanism for the Acclimation of Photosynthetic Machinery to Change in Environmental CO₂ Concentration in Eukaryotic Microalgae," 2005. <http://www.biol.tsukuba.ac.jp/~ikawa/shiraiwaHP/hp04/home04E.html>
- [49] D. O. Hessen, " Excess Carbon in Aquatic Organisms and Ecosystems: Physiological, Ecological, and Evolutionary Implications," *Limnology and Oceanography*, Vol. 53, No. 3, 2008, pp. 1685-1696. doi: 10.4319/lo.2008.53.4.1685
- [50] M. Tsuzuki, M. Gantar, K. Aizawa and S. Miyachi, " Ultrastructure of *Dunaliella Tertiolecta* Cells Grown under Low and High CO₂ Concentrations," *Plant Cell Physiology*, Vol. 27, No. 4, 1986, pp. 737-739.
- [51] E. W. Becker, " *Microalgae: Biotechnology and Microbiology*," Cambridge University Press, Cambridge, 1995.
- [52] H. E. Glover and I. Morris, " Photosynthetic Characteristics of Coccoid Marine Cyanobacteria," *Archives of Microbiology*, Vol. 129, No. 1, 1981, pp. 42-46. doi:10.1007/BF00417177
- [53] D. H. Pope, " Effects of Light Intensity, Oxygen Concentration, and Carbon Dioxide Concentration on