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Polymer-immobilized microalgae for removing nitrogen and phosphorus from water

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INTRODUCTION

Microalgae are mostly suspension-type microorganisms and are potentially useful as agents for treating all types of contaminated water. One of the major practical limitations of microalgal cultivation systems that are currently used is harvesting the biomass from the treated water. An efficient removal system is the key for recycling of water. Immobilization in polymers can solve this problem.

Most of the general techniques for immobilizing microorganisms can be easily modified and applied to microalgae, adding a design factor that these are photosynthetic microorganisms. Immobilization of microalgae for water treatment is based on the principle of keeping living cells metabolically active as long as possible within a gel matrix. After absorption of contaminants by microalgae, the treated water diffuses from the polymers and the water is reused. The cleaning process of the water is repeated for several cycles. Consequently, many polymers can fulfill the requirements as a matrix for immobilization.

Several synthetic (acrylamide, polyurethane, polyvinyl, resins) and natural polymer derivatives of algal polysaccharides (alginate, carrageenan, agar, agarose), and chitosan have been tried. Any material that is used must be hydrophilic, allowing water to diffuse into the bead. The most commonly used polymers are alginate and carrageenan, even though natural polymers are less stable in some waters than synthetic polymers.

Nitrogen and phosphorus are the major contaminant of many polluted waters. Nitrogen is biologically removed from water in two major ways. (1) Uptake of nitrogenous compounds in an assimilative way by microorganisms and larger organisms concentrates the nitrogen in biomass and leaves the water cleaner. (2) Oxidation of ammonium to nitrate, nitrite, and nitrous oxide eventually forming gaseous nitrogen that diffuses to the atmosphere. Phosphorus is more difficult to remove. Currently, the main commercial processes for removing phosphorus are chemical precipitation with iron, alum, or lime. In all cases, phosphorus is removed by converting phosphorus ions in contaminated water into a solid fraction.

Biological removal of nutrients involves bacterial and microalgal processes, either alone or combined. Removal of nutrients by suspension of free-living microalgae is the predecessor of immobilization processes. Immobilization is especially important in water treatment because it solves the problem of removing accumulated biomass produced by the suspended microalgae.

The most unusual combination of microalgae and bacteria suggested so far for contaminated water treatment is to use agricultural plant growth-promoting bacteria (PGPB) to enhance the growth and nutrient-removing capacity of microalgae. The underlying hypothesis assumes that the bacteria enhance the performance of unicellular plants (microalgae) and the plant will respond to bacterial inoculation similar to higher plants.

This presentation focuses on current studies of removing nitrogen and phosphorus from contaminated water. This includes performance of the system that combines microalgae with bacteria to clean contaminated water in medium scale autotrophic and heterotrophic bioreactors, mechanical and physiological interactions between water-treating agents (microalgae and bacteria), the natural microbial populations of contaminated water, and the detailed interaction between the two microbial agents in polymeric beads.

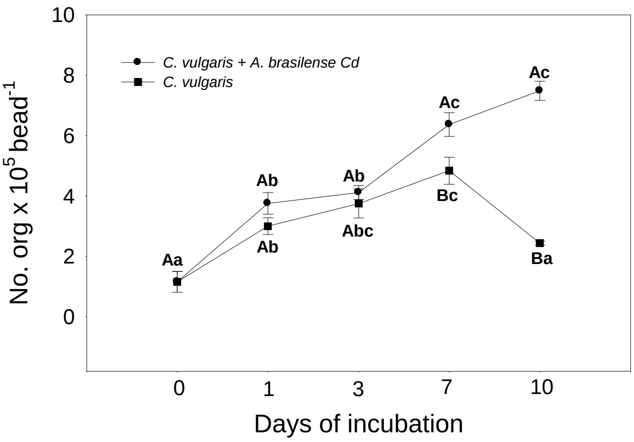

Figure 1. Growth of the microalgae *Chlorella vulgaris* immobilized in alginate beads alone or jointly with the microalgae growth-promoting bacterium *Azospirillum brasilense*. Values on each curve denoted with a different lower case letter differ significantly by one-way ANOVA. Values for each incubation date denoted with different capital letters differ significantly by Student's *t*-test.

RESULTS

Immobilization of *Chlorella vulgaris* (or *C. sorokiniana*) with the PGPB *Azospirillum brasilense* in small alginate beads significantly enhanced all growth parameters of these microalgae (Fig. 1). These artificial combinations have not been found in natural habitats; hence there are profound changes in many cytological, physiological, and biochemical pathways and metabolites within microalgal cells. Immobilization in semi-continuous, synthetic growth media under continuous cultivation significantly reduced ammonium and soluble phosphate ions in the water, compared to immobilized microalgae that were not combined with bacteria (Fig. 2 a, b).

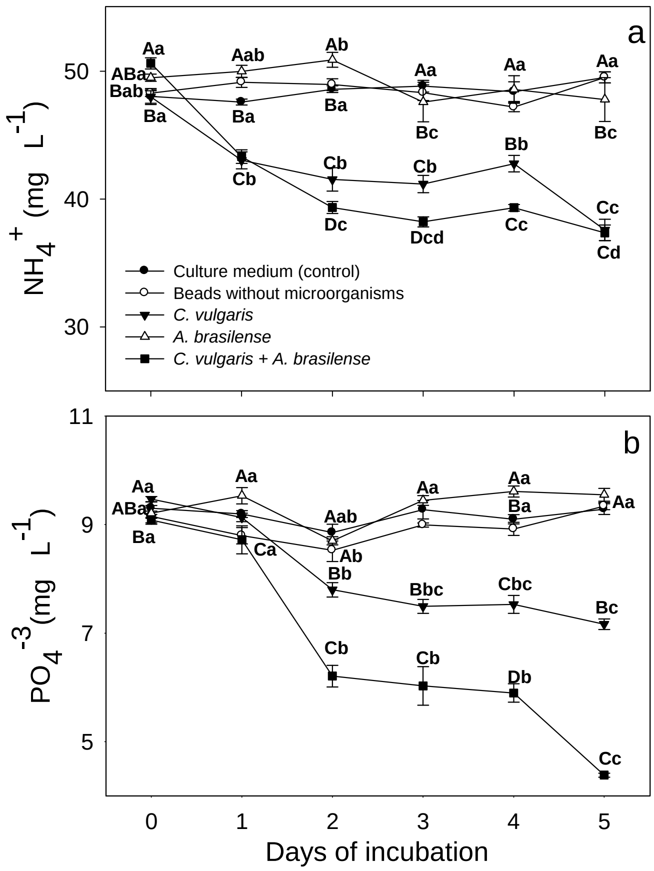

Figure 2. Uptake of ammonium (a) and phosphorus (b) on day 3 of incubation by *Chlorella Vulgaris*, when immobilized alone or jointly with *Azospirillum brasilense* under autotrophic growth conditions in synthetic growth medium. Values on each curve denoted with a different lower case letter differ significantly by one-way ANOVA. Values for each day of incubation denoted with different capital letters differ significantly by one-way ANOVA.

CONCLUSIONS

- Immobilization of water treating agents in alginate beads is suitable for reducing nutrients in contaminated water.
- The treating agents are interacting with each other within the bead, although both microorganisms are immobilized.

REFERENCES

- de-Bashan, L.E., and Bashan Y. 2008. *Joint immobilization of plant growth-promoting bacteria and green microalgae in alginate beads as an experimental model for studying plant-bacterium interactions.* Applied and Environmental Microbiology 74: 6797–6802
- de-Bashan, L.E., and Bashan, Y. 2010. *Immobilized microalgae for removing pollutants: Review of practical aspects.* Bioresource Technology 101: 1611–1627
- Perez-Garcia, O., de-Bashan, L.E., Hernandez, J.-P., and Bashan, Y. 2010. *Efficiency of growth and nutrient removal from wastewater by heterotrophic, autotrophic, and mixotrophic cultures of Chlorella vulgaris jointly immobilized with Azospirillum brasilense.* Journal of Phycology (In press) DOI: 10.1111/j.1529-8817.2010.00862.x