

Microalgal Biomass Production Using Industrial Wastewater



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Converting rainforests, peatlands, savannas, or grasslands to produce food-based BIOFUELS in Brazil, Southeast Asia, and the United States creates a 'biofuel CARBON DEBT' by **releasing 17 to 420 times more CO₂** than the annual greenhouse gas (GHG) reductions these BIOFUELS provide by displacing fossil fuels.

Algae is a better biomass source for biofuels
...Unlike biofuel crops they do not contribute to carbon debt



The screenshot shows the top portion of a TIME magazine article. The header features the TIME logo in large white letters on a red background, with "IN PARTNERSHIP WITH CNN" to its right. A search bar is located to the right of the logo. Below the header is a navigation menu with links for HOME, U.S., WORLD, BLOGS, BUSINESS & TECH, GLOBAL BUSINESS (marked as "New!"), HEALTH & SCIENCE, and ENTERTAINMENT. A banner image shows a green field with a "WM" logo and a "REPLAY" button. The article title "The Trouble With Biofuels" is prominently displayed in black. Below the title, it says "By BRYAN WALSH" and "Thursday, Feb. 14, 2008". A photograph of a cornfield is shown on the left. To the right of the photo is a "Click to listen" button with a play icon and a volume icon, followed by "Download | Subscribe at iTunes". Below the photo, the text reads "The cornfield at Didier Farms in Prairie View, Illinois." and "TIM BOYLE / GETTY". At the bottom right, there is an "ARTICLE TOOLS" section with icons for Print, Email, Reprints, and Sphere. The beginning of the article text is visible at the bottom: "Maybe it was simply too good to be true. For proponents, biofuels — petroleum substitutes made from plant matter like corn or sugar cane — seemed to promise everything. Using biofuels rather than oil would reduce the greenhouse gases that accelerate global warming, because plants absorb

Ref: Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change.
T. Searchinger, R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T.-H. Yu (2008)
Science **319**, 1238-1240

Research Objective

- To examine the potential of carpet industry wastewater as growth medium for microalgae cultivation production

Approach

- Characterization of wastewater (Raw and Treated)
- Isolation and identification of native strains of microalgae for biomass and biofuels production
- Studies on seasonal variations in species composition in carpet industry wastewater industrial wastewater
- Comparison of monoculture system with mixed culture system for biomass production using wastewater and standard growth medium through:
 - Preliminary screening of various algal strains
 - Timescale batch studies using selected algal strains

Seasonal Variations in Species Composition (%) of Raw and Treated Industrial Wastewaters

Strains identified	Spring		Fall	
	Treated	Raw	Treated	Raw
<i>Aphanocapsa delicatissima</i>	nil	0.02	nil	nil
<i>Aphanothece spp .</i>	nil	0.12	nil	nil
<i>Chroococcaceae spp .</i>	0.02	0.81	nil	nil
<i>Chroococcus minutus</i>	0.05	nil	nil	nil
<i>Leibleinia kryloviana</i>	nil	nil	nil	22.87
<i>Limnothrix redekei</i>	nil	nil	nil	13.5
<i>Lyngbya spp</i>	36.74	nil	nil	nil
<i>Oscillatoria tenuis</i>	1.59	nil	nil	nil
<i>Raphidiopsis curvata</i>	nil	nil	71.11	0.55
<i>Synechococcus elongatus</i>	nil	0.11	nil	nil
<i>Synechococcus sp.1</i>	0.06	0.35	nil	nil
<i>Synechocystis spp</i>	nil	0.17	nil	nil
Cyanophyta contribution	38.46	1.58	71.11	36.92
<i>Eunotia spp</i>	1.49	nil	nil	nil
<i>Navicula pelliculosa</i>	3.12	nil	nil	nil
<i>Nitzschia palea</i>	21.85	0.33	nil	nil
Bacillariophyta contribution	26.46	0.33	Nil	Nil

Seasonal Variations in Species Composition (%) of Raw and Treated Industrial Wastewaters

Strains identified	Spring		Fall	
	Treated	Raw	Treated	Raw
<i>Chlamydomonas spp</i>	nil	nil	1.21	57.71
<i>Chlorella vulgaris</i>	nil	nil	7.68	nil
<i>Chlorococcaceae spp</i>	12.79	0.72	nil	nil
<i>Chlorococcum humicola</i>	nil	nil	4.04	4.41
<i>Coelastrum microporum</i>	5.62	nil	2.42	nil
<i>Gloeocystis vesiculosa</i>	nil	nil	1.21	nil
<i>Monoraphidium mirabile</i>	nil	nil	3.84	nil
<i>Oedogonium spp</i>	0.23	nil	nil	nil
<i>Oocystis lacustris</i>	nil	nil	3.23	0.69
<i>Scenedesmus abundans</i>	0.09	nil	nil	nil
<i>Scenedesmus acuminatus</i>	2.61	nil	nil	nil
<i>Scenedesmus acutus</i>	3.42	11.84	nil	nil

Seasonal Variations in Species Composition (%) of Raw and Treated Wastewaters

Strains identified	Spring		Fall	
	Treated	Raw	Treated	Raw
<i>Scenedesmus acutus alternans</i>	0.75	nil	nil	nil
<i>Scenedesmus bicaudatus</i>	0.16	nil	nil	nil
<i>Scenedesmus bijuga</i>	1.59	nil	2.42	0.28
<i>Scenedesmus bijuga alternans</i>	0.23	nil	nil	nil
<i>Scenedesmus denticulatus</i>	0.13	nil	nil	nil
<i>Scenedesmus dimorphus</i>	1.87	nil	nil	nil
<i>Scenedesmus obliquus</i>	0.67	0.06	nil	nil
<i>Scenedesmus quadricauda</i>	1.29	nil	2.83	nil
<i>Scenedesmus quadrispina</i>	3.54	nil	nil	nil
<i>Scenedesmus serratus</i>	0.09	nil	nil	nil
<i>Stigeoclonium spp</i>	nil	38.84	nil	nil
<i>Uroglena spp</i>	nil	46.49	nil	nil
Chlorophyta contribution	35.08	97.95	28.88	63.09
Unknown	nil	0.14	nil	nil

Preliminary Screening

Objective:

- Assess various strains of microalgae for their growth potential in industrial wastewater.

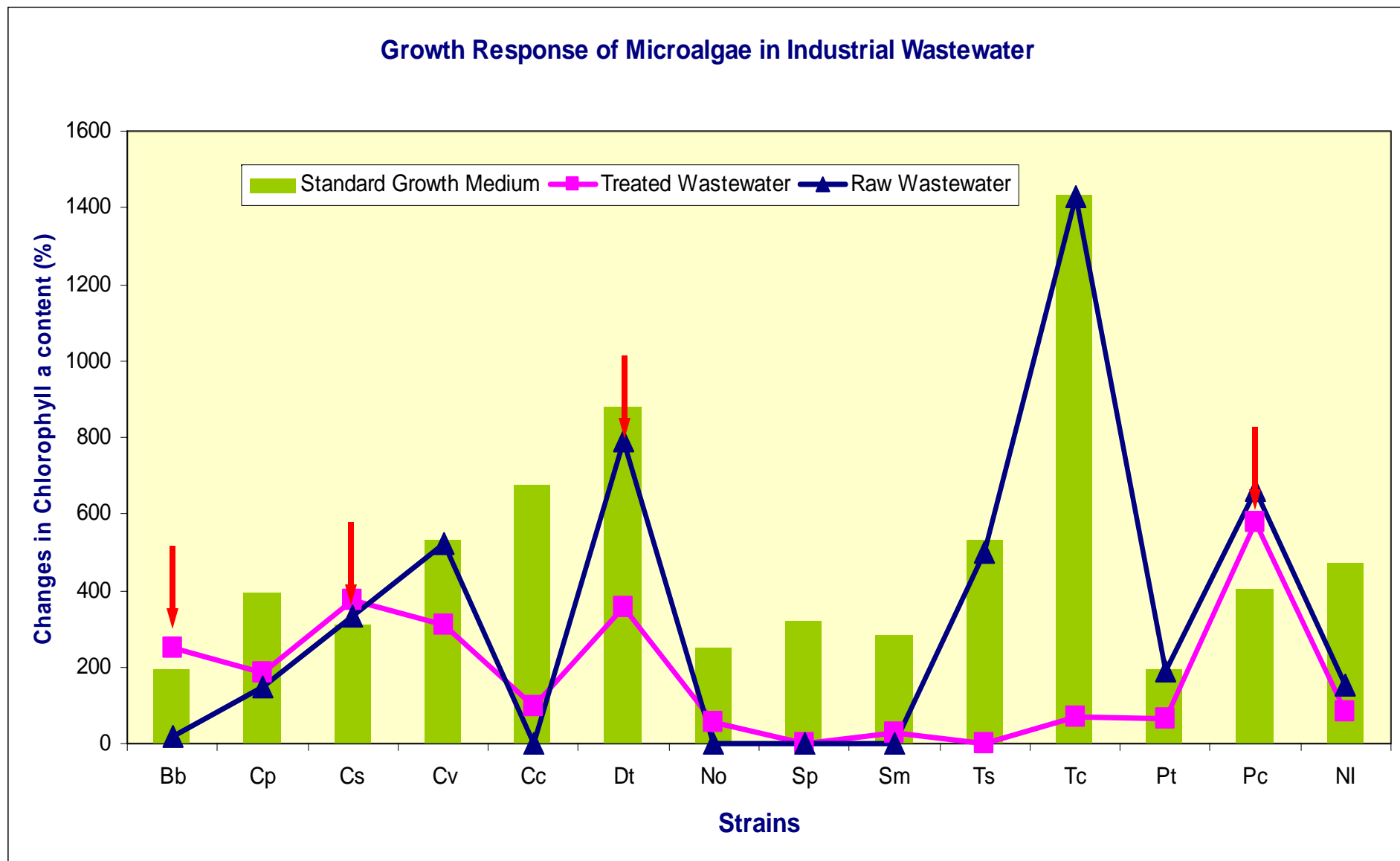
Strains Used for Preliminary Screening

Strain	Form	Standard Growth Medium
<i>Botryococcus braunii</i> UTEX 572	Fresh water	BG11
<i>Chlorella protothecoides</i> UTEX 25	Fresh water	BG11
<i>Chlorella saccharophila</i> var. <i>saccharophila</i> UTEX 2469	Fresh water	BG11
<i>Chlorella vulgaris</i> UTEX 2714	Fresh water	BG11
<i>Cricosphaera carterae</i> UTEX LB1014	Marine	Modified BG medium
<i>Dunaliella tertiolecta</i> UTEX LB999	Marine	Modified BG medium
<i>Nannochloris oculata</i> UTEX LB1998	Marine	Modified BG medium
<i>Spirulina platensis</i> UTEX LB1926	Marine algae	Modified CFTRI

Strains used for Preliminary Screening

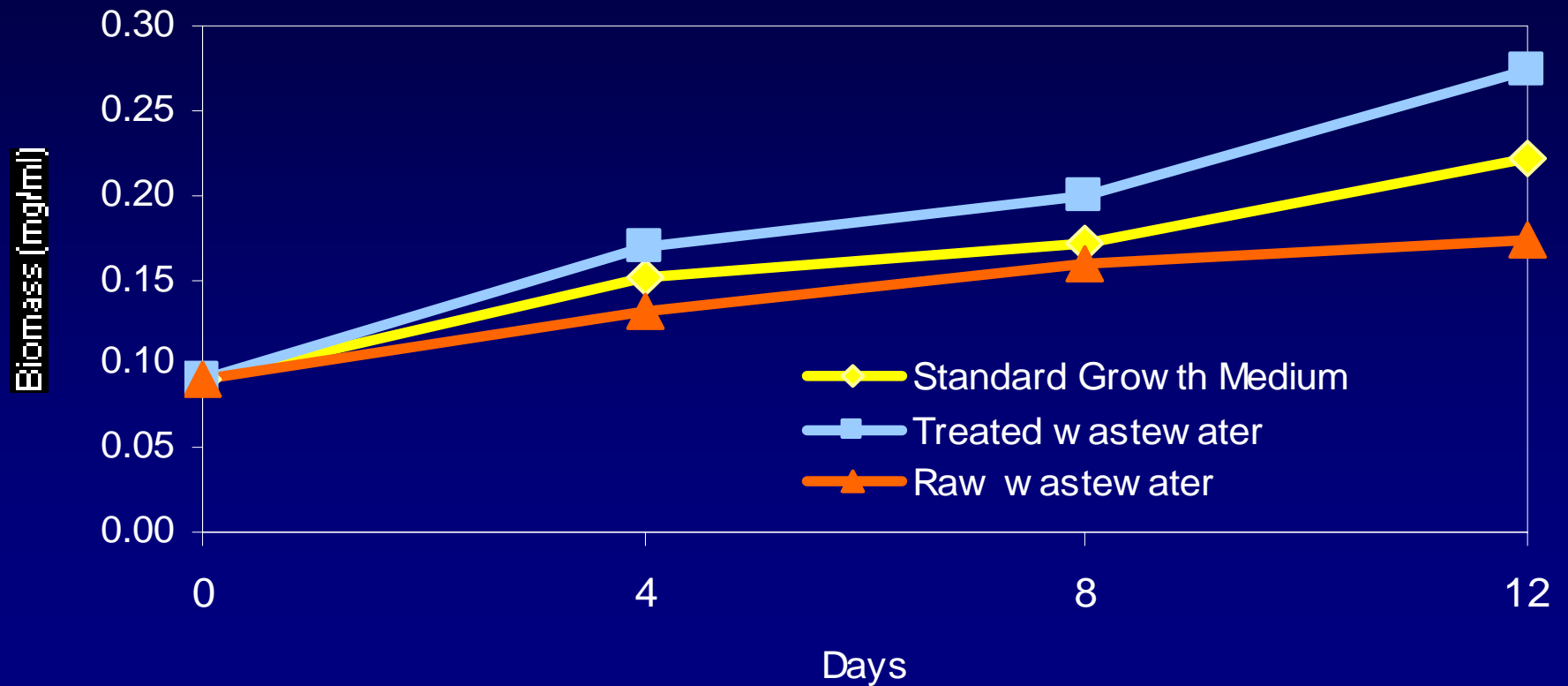
Strain	Form	Standard Growth Medium
<i>Spirulina maxima</i> UTEX LB2342	Fresh water	Modified CFTRI
<i>Tetraselmis suecica</i> UTEX LB2286	Marine	Modified BG medium
<i>Tetraselmis chuii</i> UTEX LB232	Marine	Modified BG medium
<i>Phaeodactylum tricornutum</i> UTEX 646	Marine	Modified BG medium
<i>Pleurochrysis carterae</i> CCMP 647	Marine	Modified BG medium
Consortium of native isolates from industrial wastewater	Fresh water	BG11

Changes in chlorophyll content (%) of various strains of microalgae grown in industrial wastewater

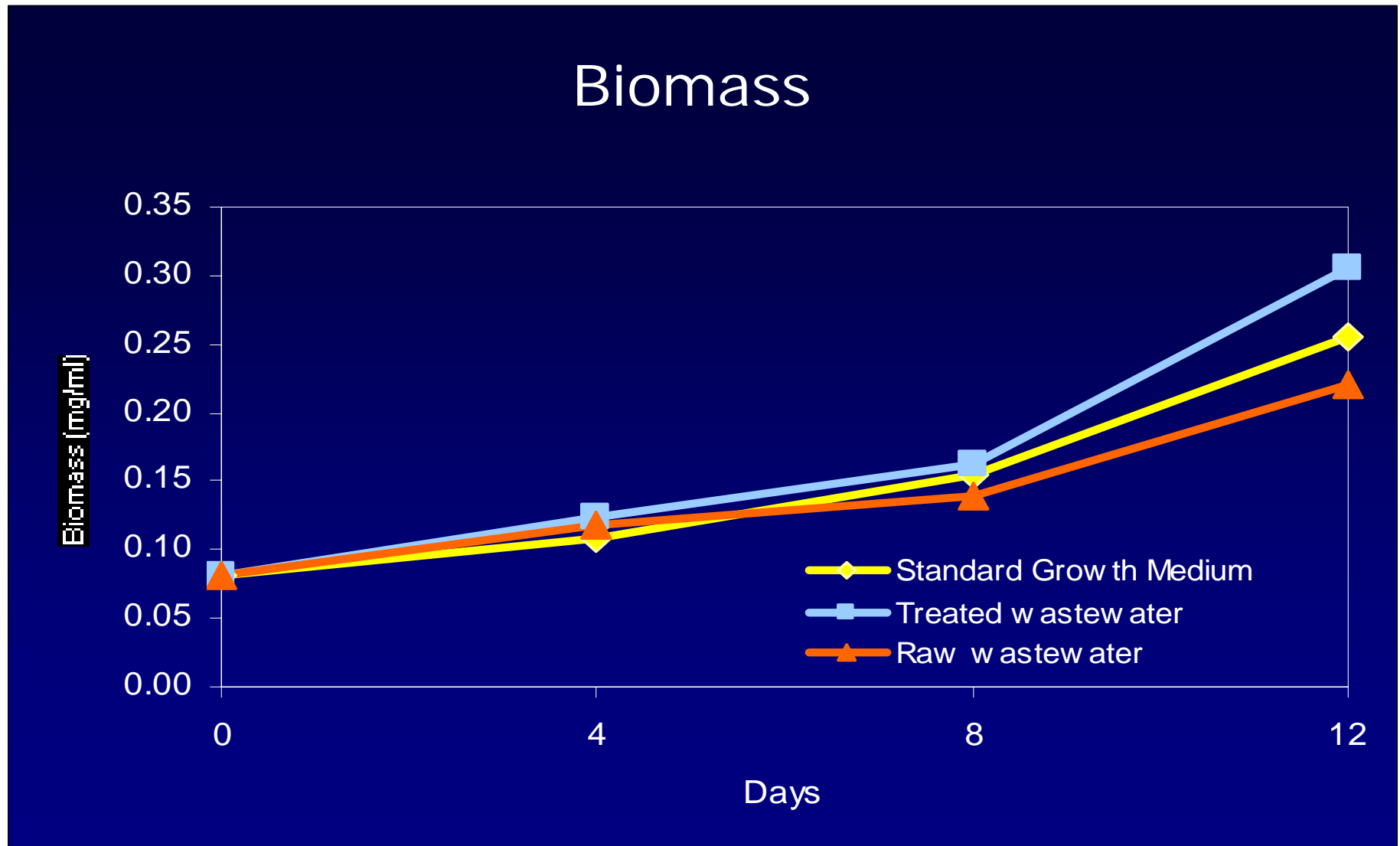


Time dependent changes in biomass content of *B.braunii* grown in industrial wastewater

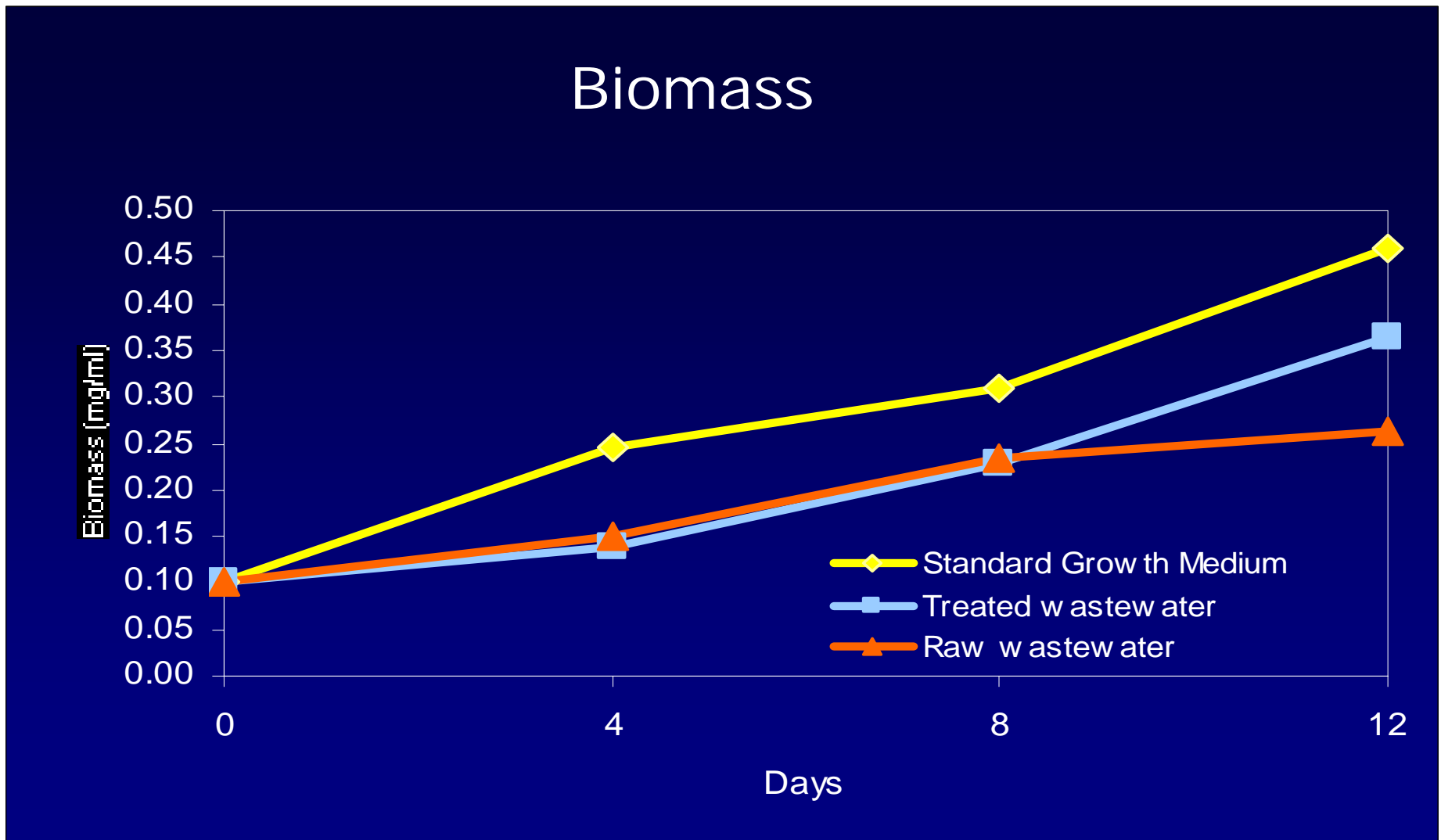
Biomass



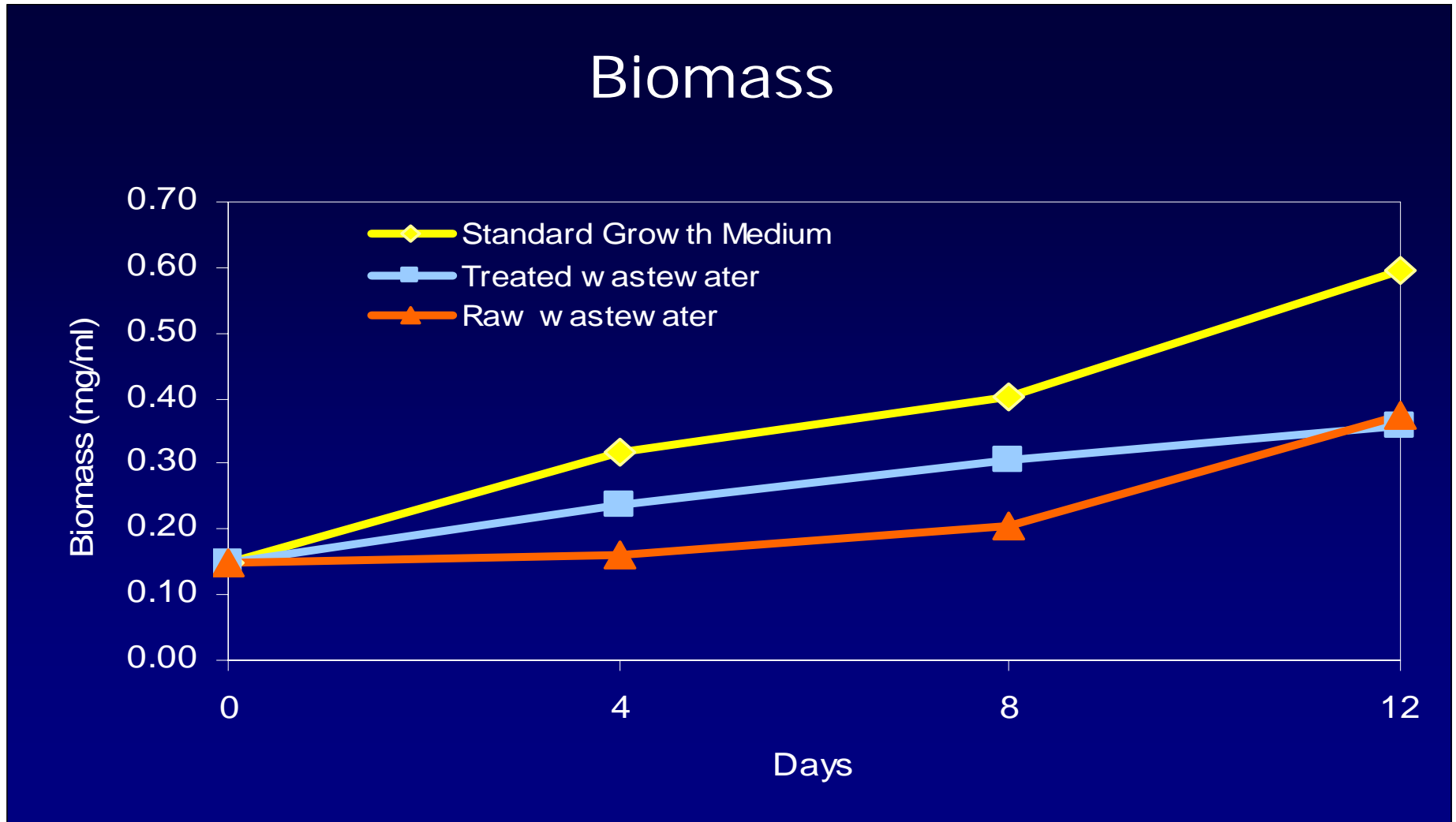
Time dependent changes in biomass content of *C.saccharophila* grown in industrial wastewater



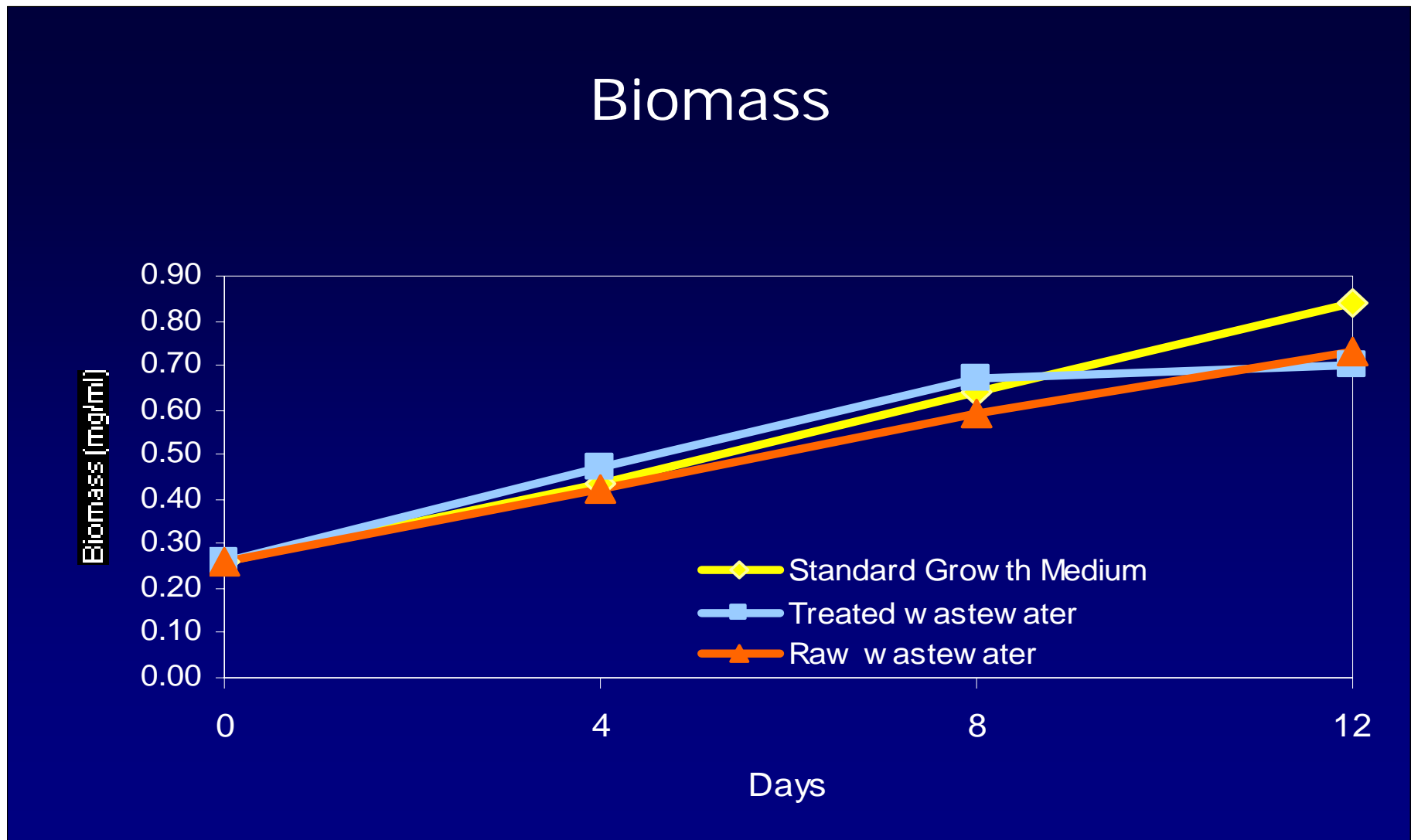
Time dependent changes in biomass content of *D.tertiolecta* grown in industrial wastewater



Time dependent changes in biomass content of *P.carterae* grown in industrial wastewater



Time dependent changes in biomass of *consortium of natural isolates* grown in industrial wastewater



Summary

- Growth performance of strains *Botryococcus braunii* and *Chlorella saccharophila* was better in treated wastewater than standard growth medium and raw wastewater in terms of biomass production
- Species belonging to Chlorophyta (green algae) and Cyanophyta (blue green algae) dominate carpet industry wastewater
- Consortium of native isolates of carpet industry wastewater showed great potential for biomass production
- Treated carpet industry wastewater used in the experiment is a good growth medium for microalgae cultivation

Future Work

- Detailed studies on seasonal variation in species composition in the treated wastewater
- Standardization of ideal consortium composition for cultivation of algae in wastewater for biomass and biofuels production
- Continuous scale studies with various levels of CO₂ to evaluate biomass and lipid production of selected algal cultures and mixed consortium of native isolates using carpet industry wastewater

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