PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Modelling the effect of environmental conditions on microalgae’s growth during continues culture

Student: Héctor Zúñiga

Professor Guide: David Jeison

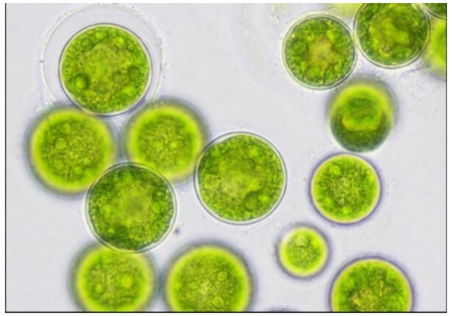
Andrés Donoso Bravo

Contents

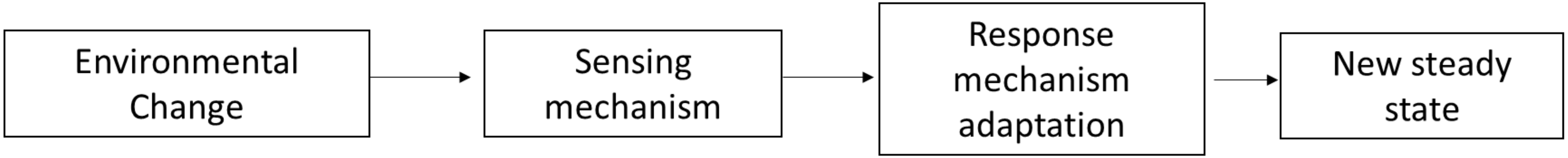
PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Introduction

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO



- Response to stimuli or change in its environment is an inherent characteristic of any living organism

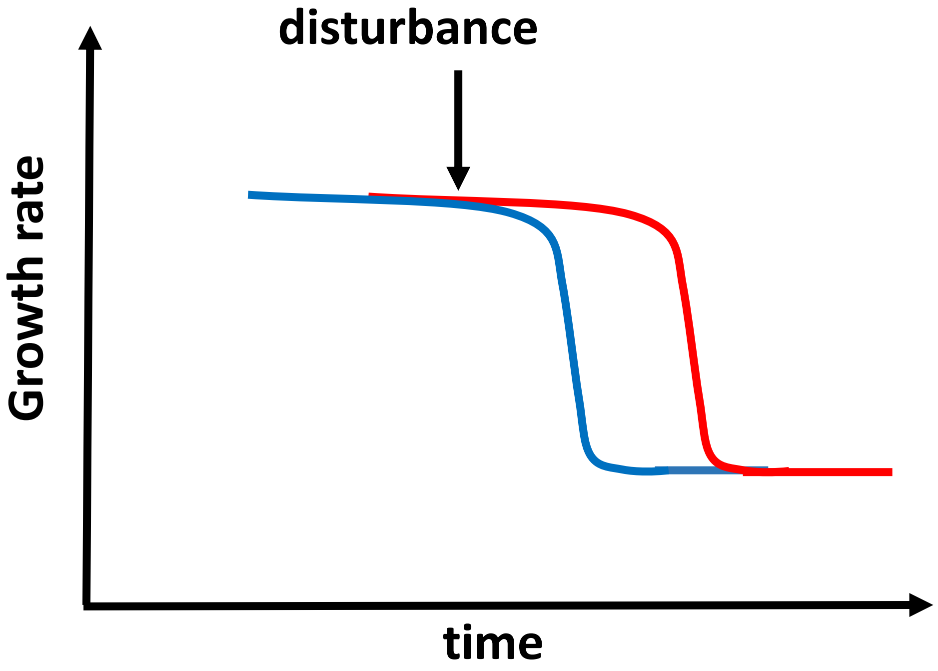


- The study of the response of a microbial culture against dynamic conditions can be important for the operation,desing and control of bioprocess

Bibliographic background

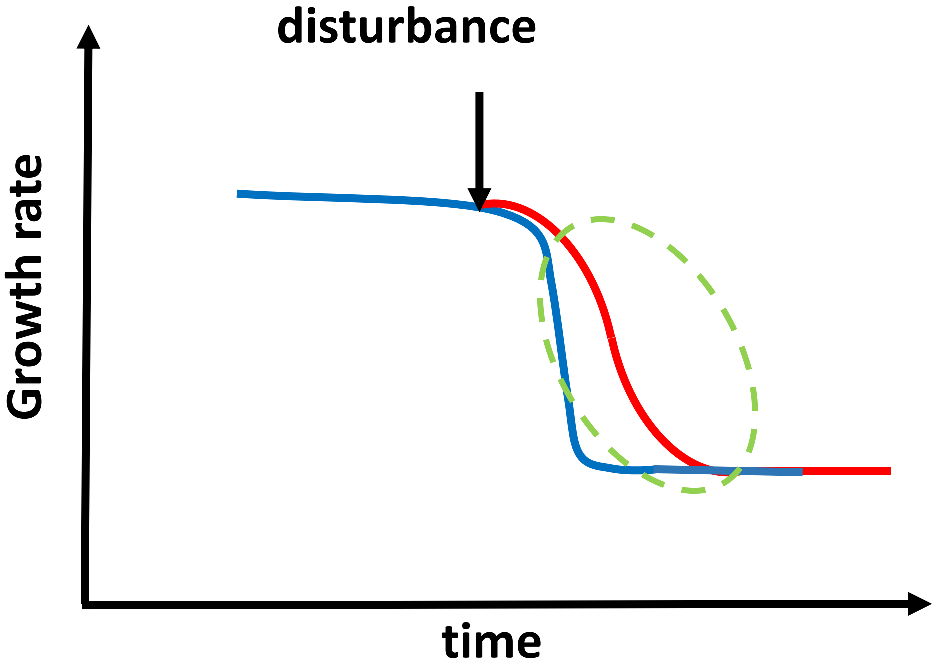
Discrete delay

$$\mu = \frac{\mu_{máx}\, s(t-\tau)}{k_s + s(t-\tau)}$$



Distributed delay

$$\mu = \int_{-\infty}^{t} \frac{\mu_{máx}}{k_s + s(\theta)} * (s(\theta)) e^{(-D(t-\theta))}$$



Bibliographic background

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Previous studies	Year	microorganism	Study variable	classifications	report
Caperon	1969	*Isochrysis galbana*	Dilution rate	Discrete delay	14 , 32 (hr)
Rodin et. al.	1990	*E. coli*	Carbon source	Discrete delay	4 (hr)

Bibliographic background

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Previous studies	Year	microorganism	Study variabe	classifications	report
Ellermeyer et. al.	2003	*E. Coli* ATCC 23716	Carbon source	Distributed delay	20 (min)
Segura et. al.	2017	*Chlorella sorokiniana*	Inhibitor growth effect		20 to 60 (hr)

General objetive

- ✓To study the existence of a delay in the growth response of microalgae in the face of changes in operating conditions.

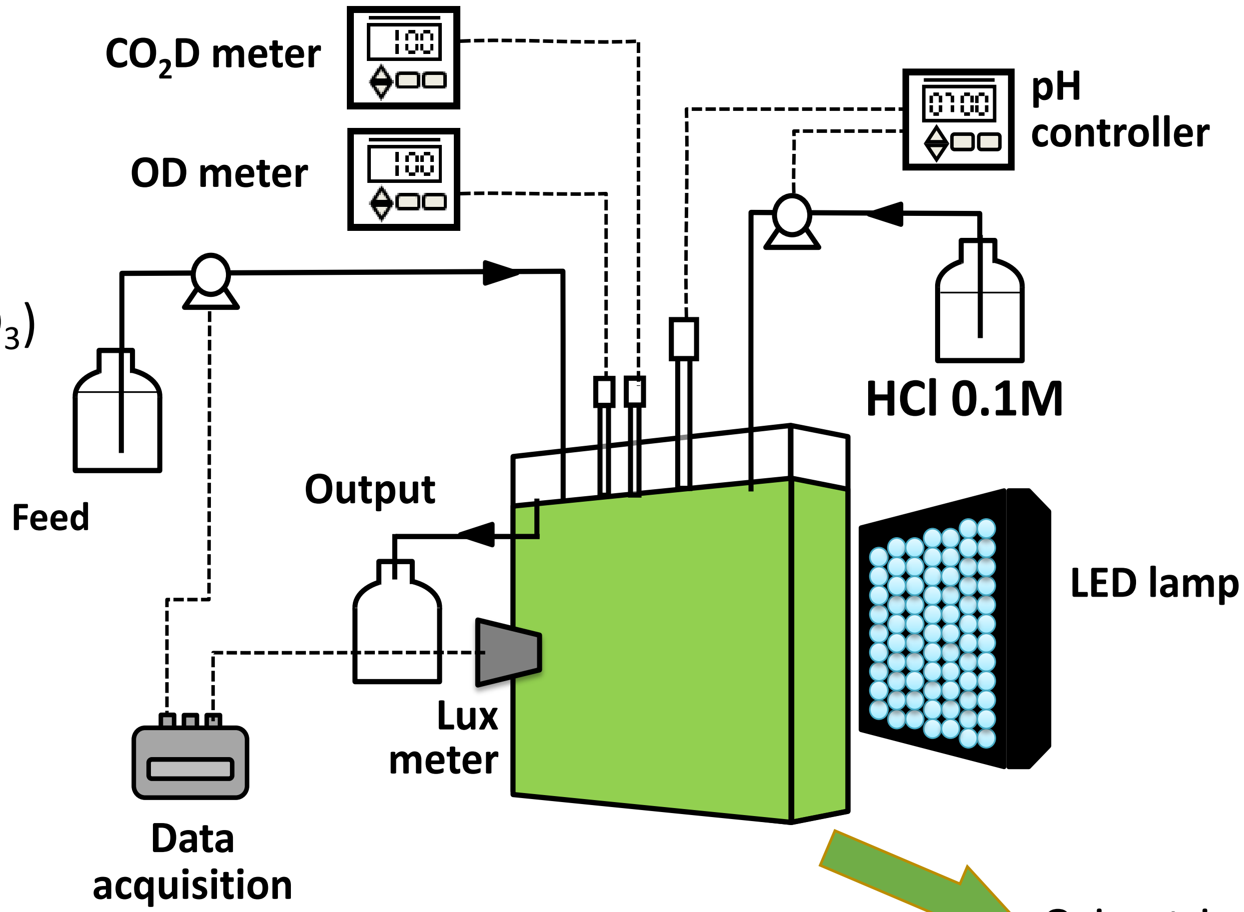
Specific objectives

- ✓To analyze the delay response by changes in the availability of carbon and energy source

- ✓Modelling of effect the environmental conditions on microalgae's growth.

Microalgae culture

Carbon source
Disturbaces ($NaHCO_3$)



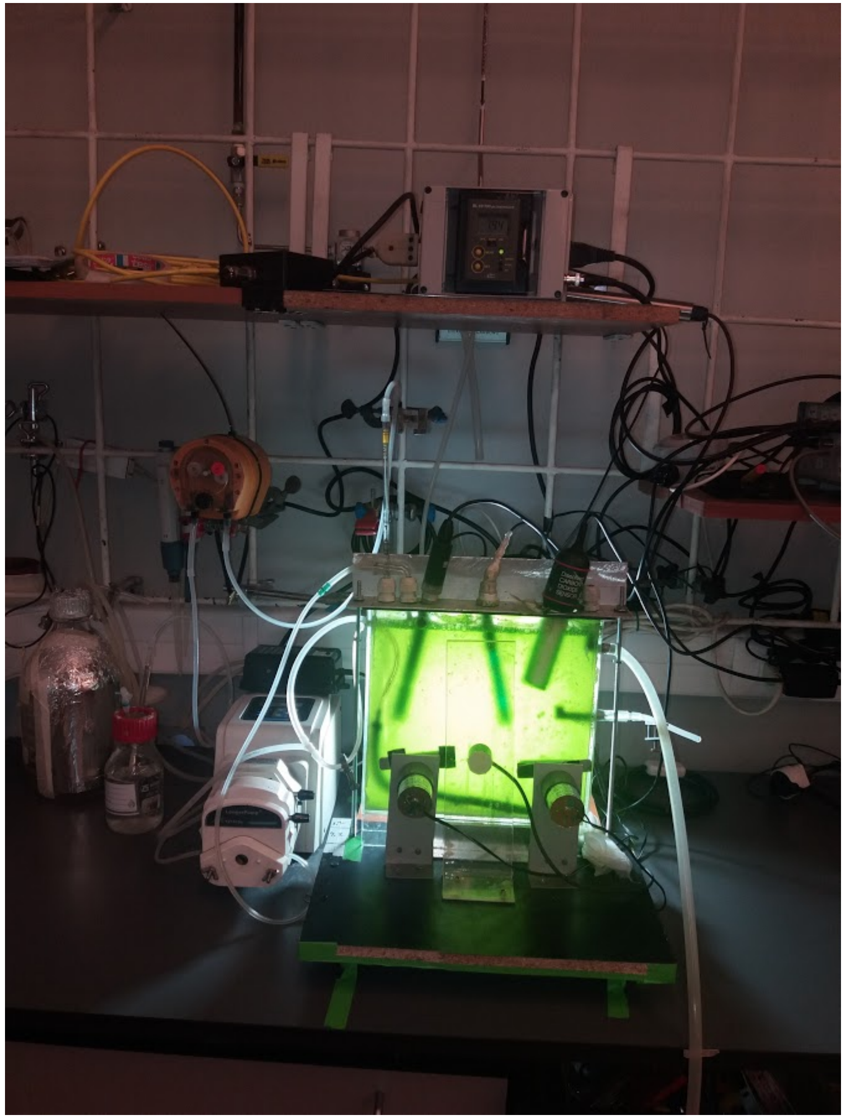
Light source disturbances

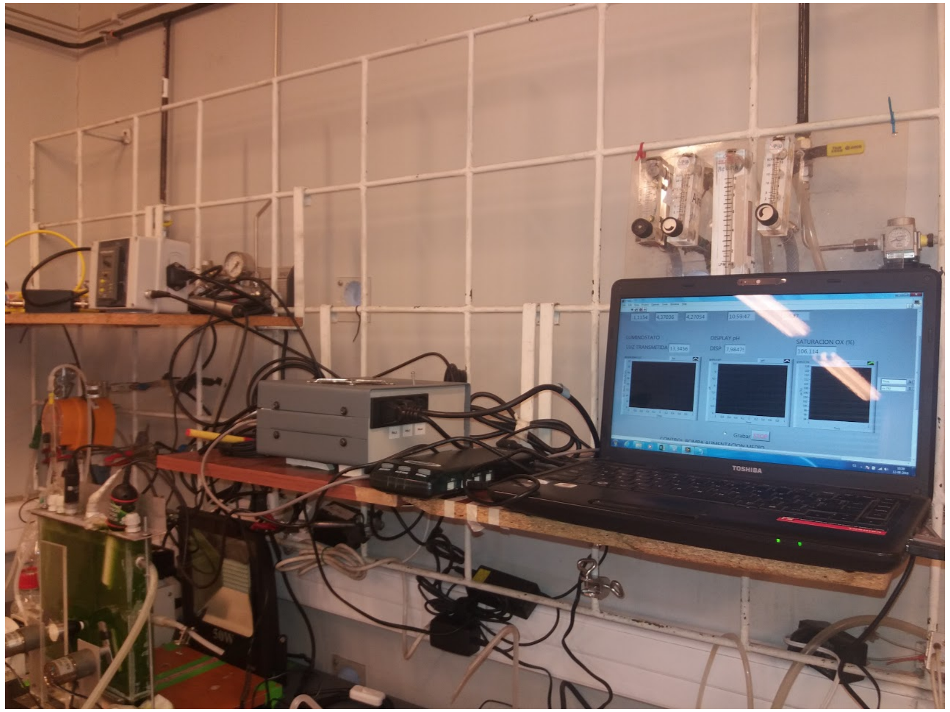
Oximetri essays

Methodology

Microalgae culture

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO





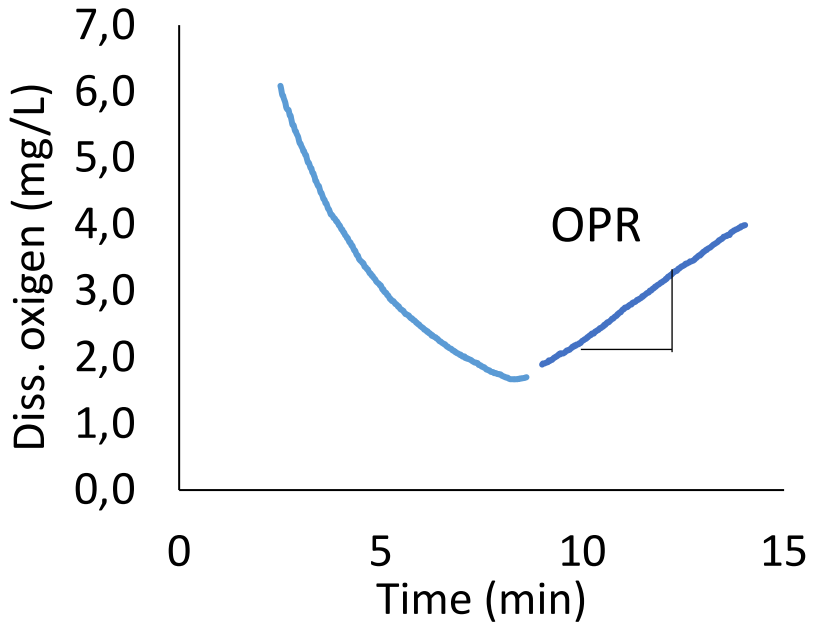
Methodology

Oximetri essays

Growth response

$$\frac{dC_L}{dt} = OPR + k_L a(C_L^* - C_L) - r_e$$

$$OPR = Y_{O_2}(\mu\, x)$$



Methodology

Analytic methods

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Parameter	Methodology
Biomass concentration	Spectrophotometer (540nm).
Total inorganic carbon	Titrimeter A-B (Std. Meth. 3220)
OD-CO_2D	Sensor (Data acquisition)

Methodology

Modeling

Decostere et al.(2013)

Process	dx/dt	$dHCO_3^-/dt$	dCO_2/dt	dCO_3^{2-}/dt	dO_2/dt	Process rate
1. Growth on HCO_3^-	1	$-1/Y_{HCO_3^-}$			Y_{O_2}	$\mu_{max}\left(\frac{HCO_3^-}{K_{HCO_3^-}+HCO_3^-}\right)\left(\frac{K_{CO_2}}{K_{CO_2}+CO_2}\right)x$
2. Growth on CO_2	1		$-1/Y_{CO_2}$		Y_{O_2}	$\mu_{max}\left(\frac{CO_2}{K_{CO_2}+CO_2}\right)x$
3. Microalgae decay	-1					$b_{max}\ x$
4.Transfer rate O_2					1	$k_La\ (O_2^*-O_2)$
5.Transfer rate CO_2			1			$k_La\sqrt{DCO_2/DO_2}\ (CO_2^*-CO_2)$
6. CO_2 hydratation		61	-44			$k_1\left(\frac{CO_2}{44}-10^{-pH}\frac{HCO_3^-}{61\ K1}\right)$
7.HCO_3^- dissociation		-61		60		$k_2\left(\frac{HCO_3^-}{61}-10^{-pH}\frac{HCO_3^-}{60\ K2}\right)$
8. Endogenous respiration					1	$r_e\ x$

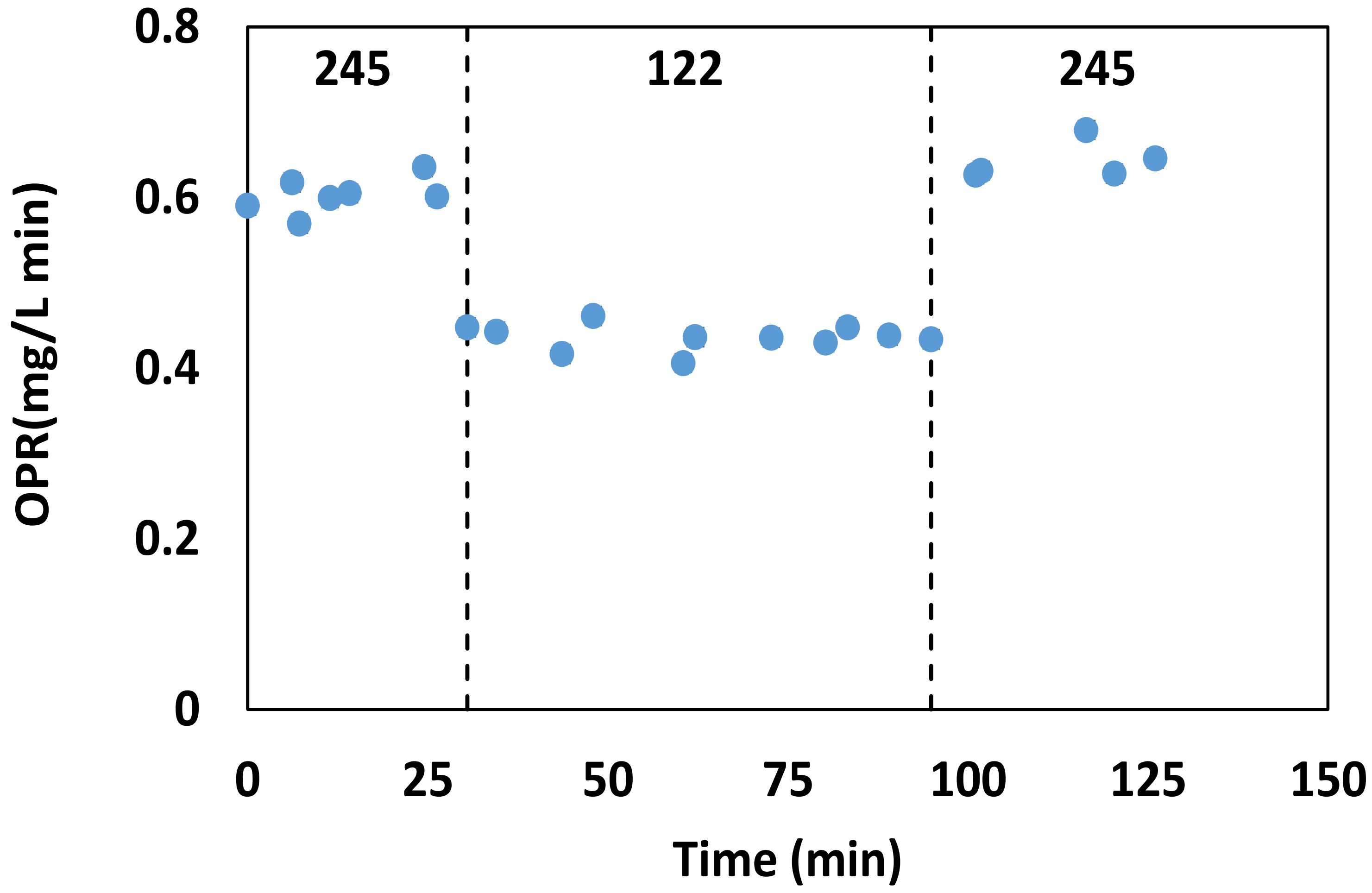
Environmental disturbances

Incident light ($\mu mol/m^2s$)
122 (-50%)
Oscuridad
367 (+50%)

TIC (mg/L)
2000
1200
500

Methodology

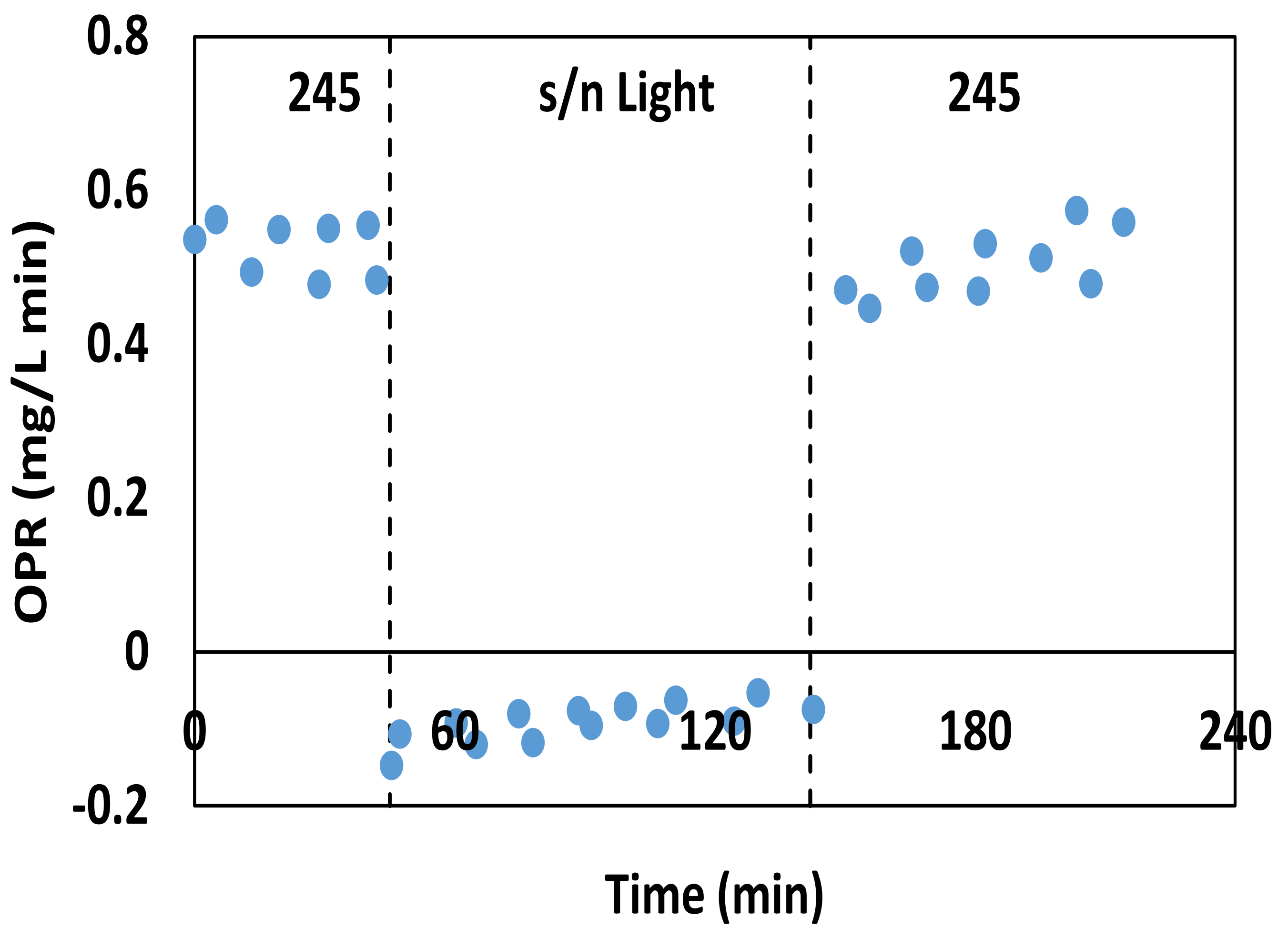
Study light source



Result

Study light source

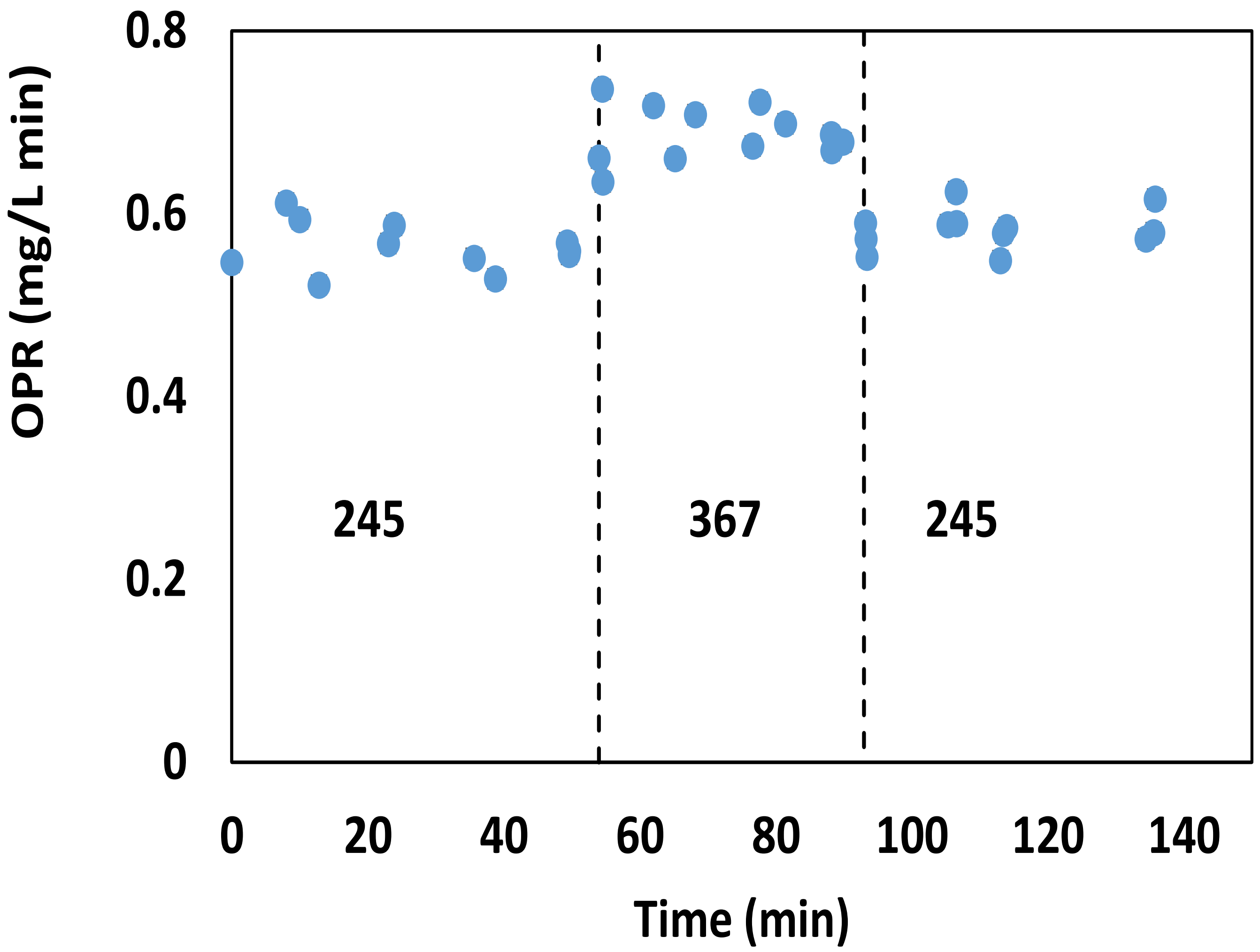
PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO



Result

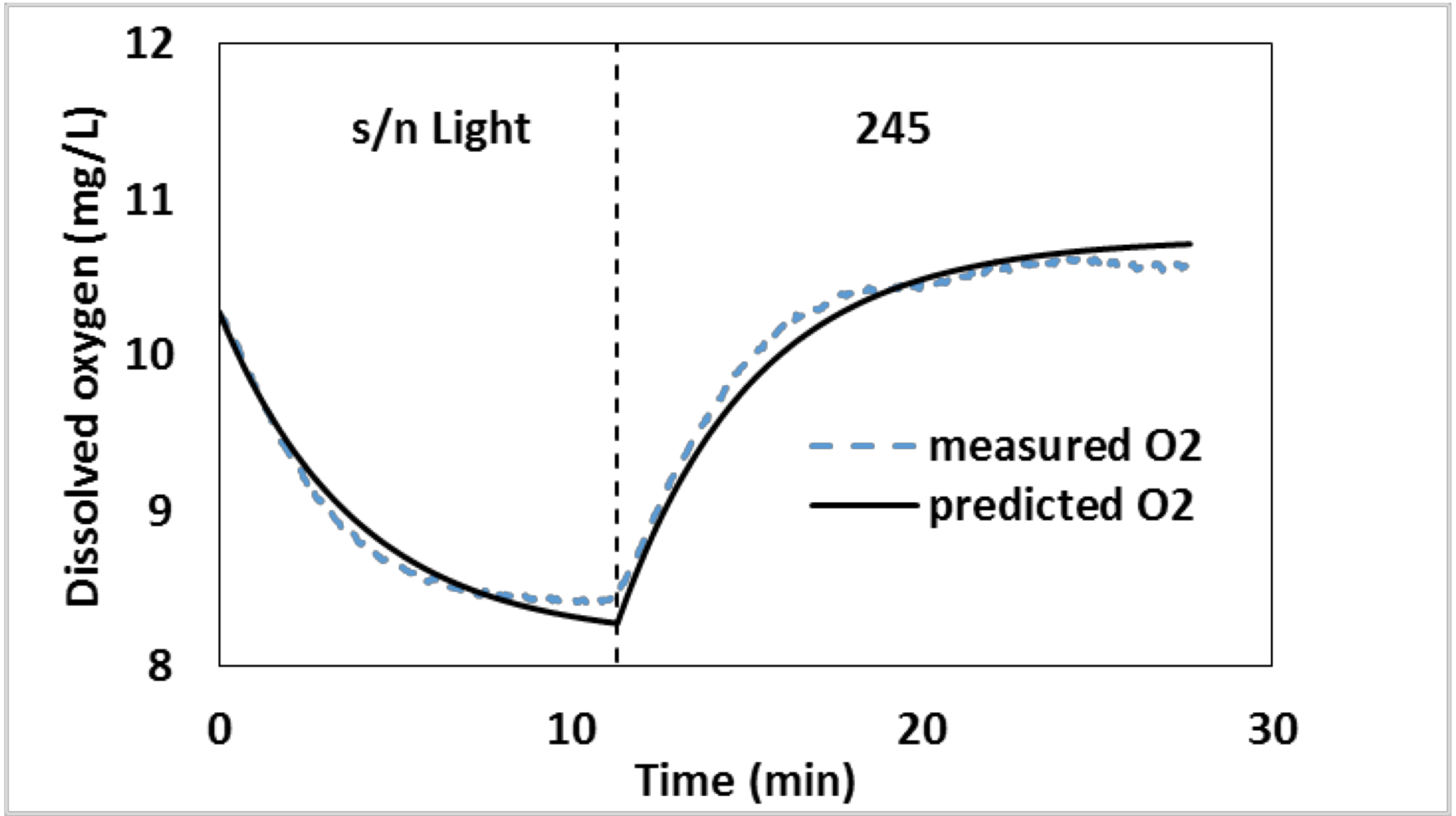
Study light source

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO



Result

Study light source



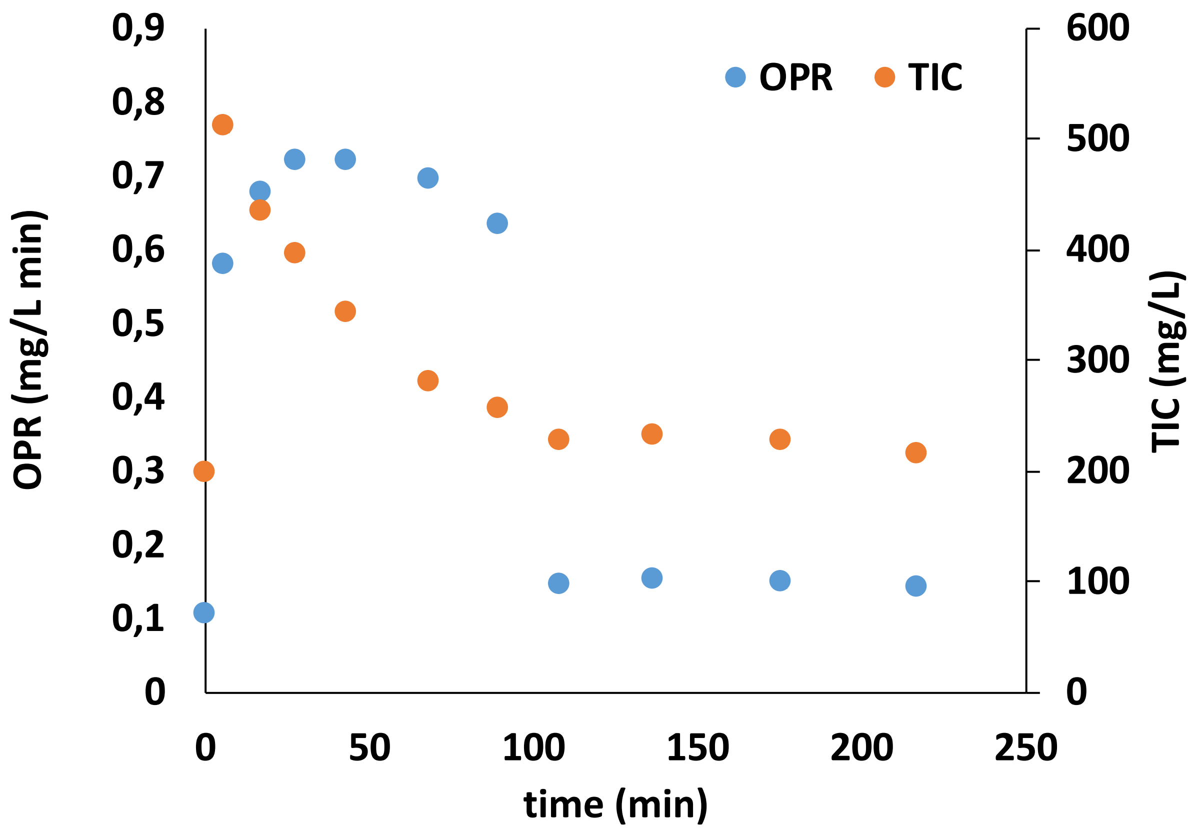
R^2 OD 0,989

Result

Study carbon source

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Pulse TIC 500 mg/L

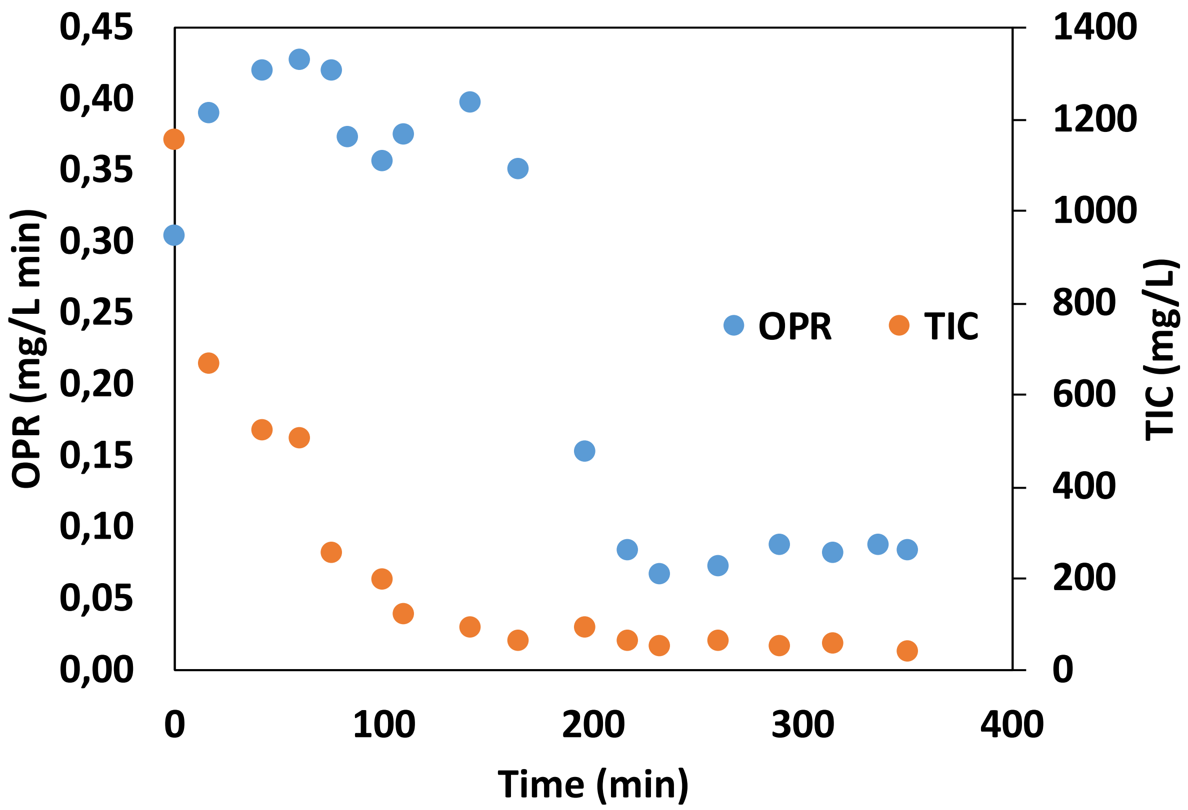


Result

Study carbon source

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

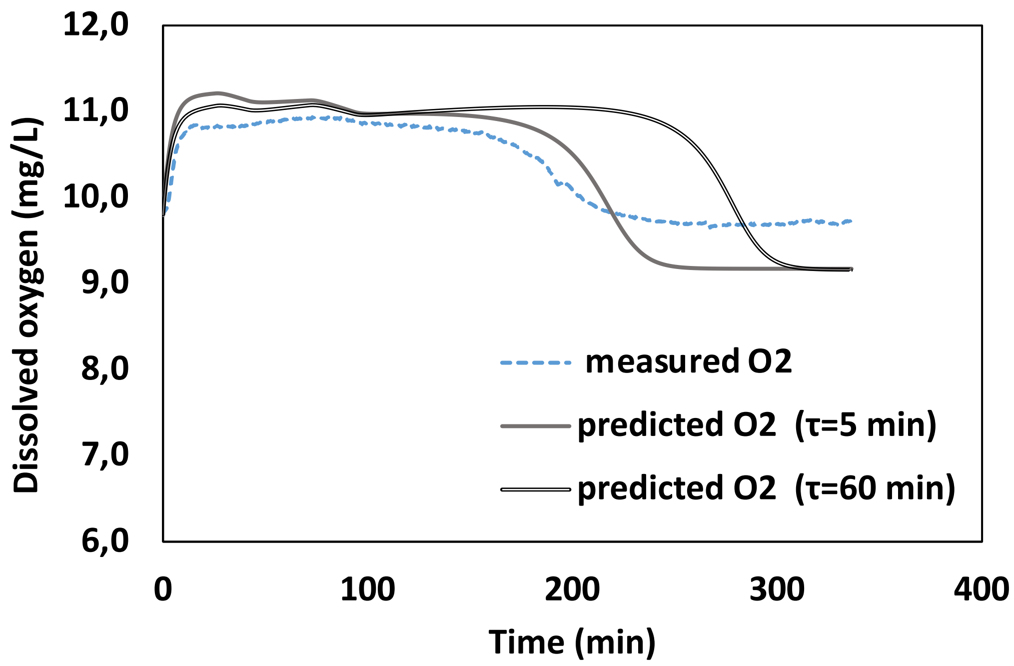
Pulse TIC 1200 mg/L

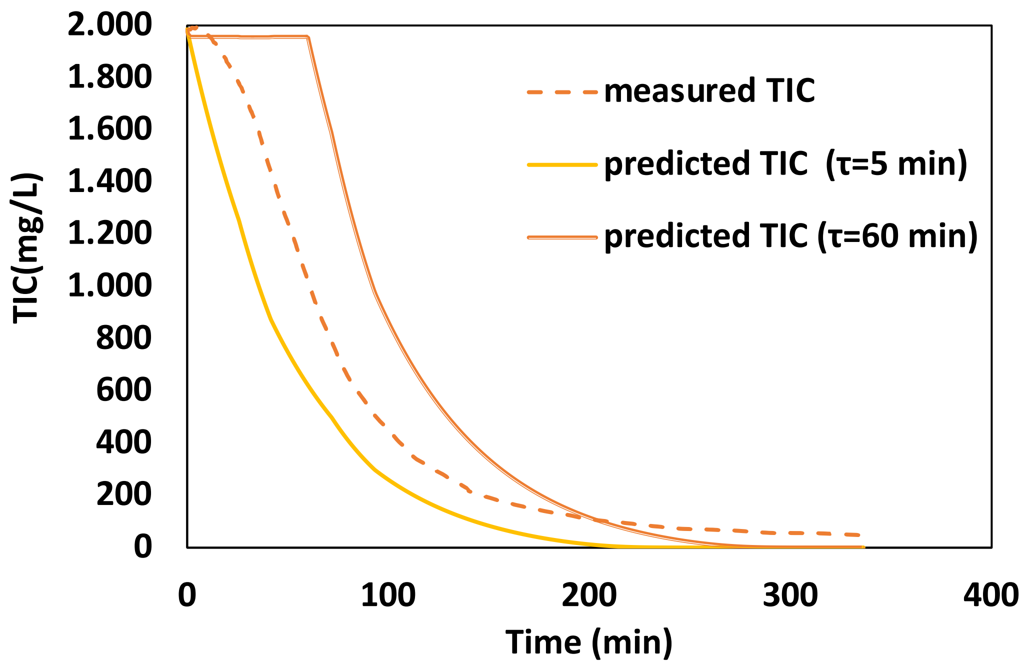


Result

Study carbon source

PulseTIC 2000 mg/L



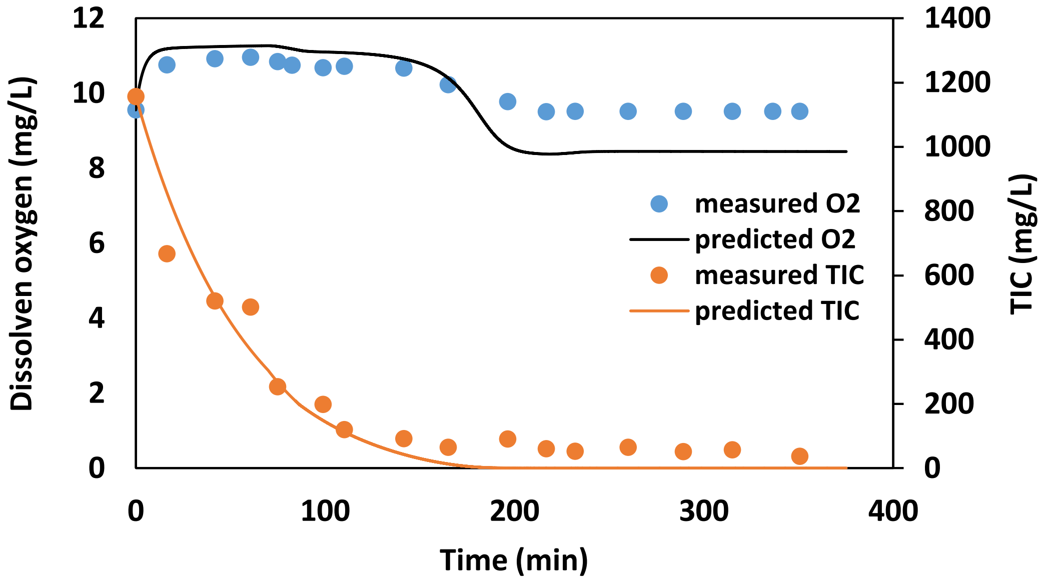


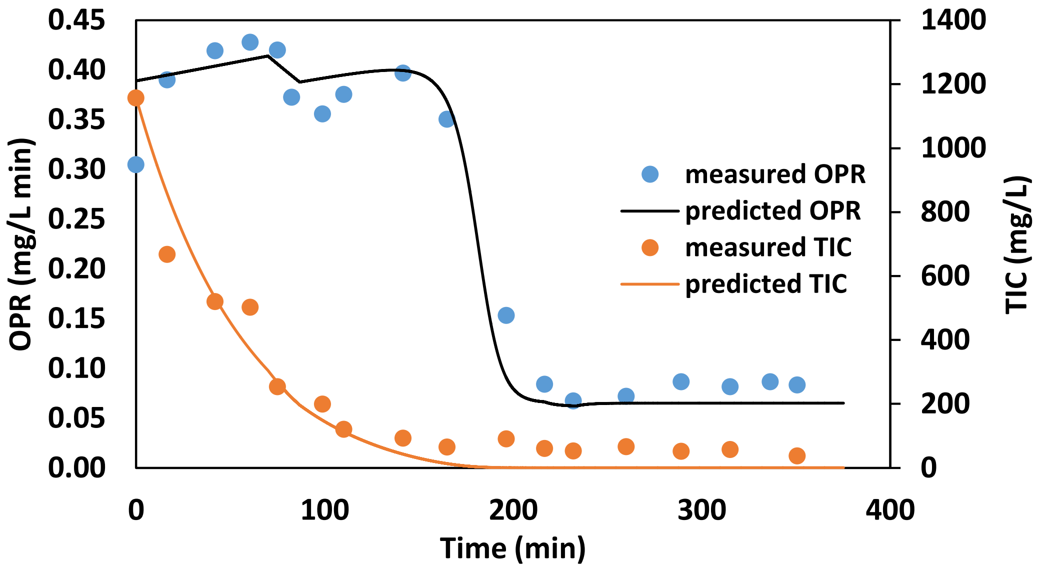
Studio	$\mu_{máx}$ (d^{-1})	Y_{x/HCO_3}	Y_{x/CO_2}	$Y_{O_2/x}$	K_{HCO_3} (mg/L)	K_{CO_2} (mg/L)	Delay (min)	R^2 DO	R^2 TIC
Thesis	0.682	0.559	0.785	1.24	4.961	0.370	5.17	0.9571	0.9867

Study carbon source

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Pulso TIC 1200 mg/L





R^2 DO 0,94

R^2OPR 0,96

R^2 TIC 0,95

Result

Conclusion

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

✓Based on the assays performed it can be concluded that microalgae presets no appreciable delays in activity response, when facing a light disturbance. Moreover, after disturbance in light intensity was removed, activity came back to its original value

✓For study of disturbance in carbon source, at delay in microbial response is observed. Such delay is in the range from several minutes to one hour. Moreover, the good performance a traditional respirometric model to represent these responses was determined.

Acknowledgments

✓Beca arancel PUCV.

✓LBA.

Modelling the effect of environmental conditions on microalgae's growth during continues culture

PONTIFICIA UNIVERSIDAD CATOLICA DE VALPARAISO

Student: Héctor Zúñiga

Professor Guide: David Jeison

Andrés Donoso Bravo