Microalgal growth in Sewage Sludge Waste

1st day

9th day

Dr. Giulio Allesina
Dr. Simone Pedrazzi
Dr. Meltem Altunoz

Strategies on microalgal growth by using various waste feedstock, benefits, areas of usage

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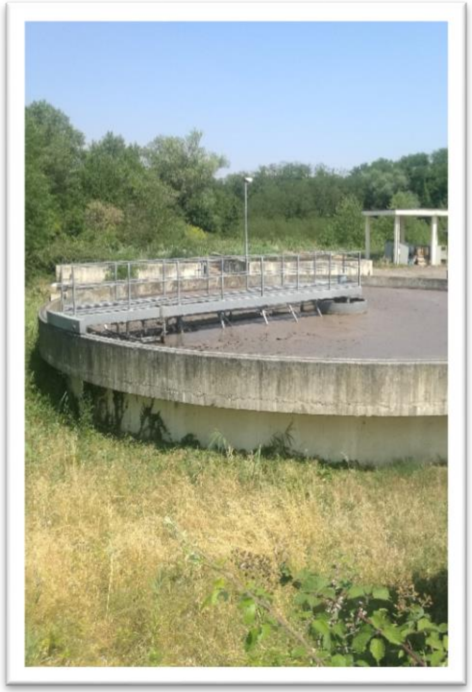
IDRA – Interdepartmental Research on Algae



Waste Use on Microalgal Growth

Purification by microalgae

Giulio Allesina, Simone Pedrazzi, Meltem Altunoz – 07-11-2017

ECOMONDO the green technologies expo

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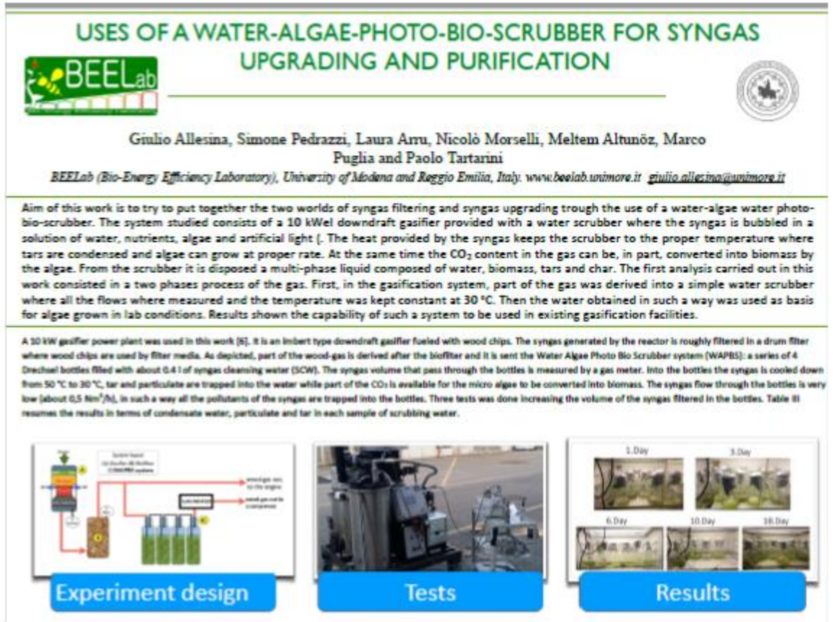
Syngas Purification
Sewage Sludge Waste Purification
Heavy metal Purification

Fornovo

Neochloris oleoabundans



USES OF A WATER-ALGAE-PHOTO-BIO-SCRUBBER FOR SYNGAS UPGRADING AND PURIFICATION

Giulio Allesina, Simone Pedrazzi, Laura Arru, Nicolò Morselli, Meltem Altunöz, Marco Puglia and Paolo Tartarini

BEELab (Bio-Energy Efficiency Laboratory), University of Modena and Reggio Emilia, Italy. www.beelab.unimore.it giulio.allesina@unimore.it

Aim of this work is to try to put together the two worlds of syngas filtering and syngas upgrading trough the use of a water-algae water photo-bio-scrubber. The system studied consists of a 10 kWel downdraft gasifier provided with a water scrubber where the syngas is bubbled in a solution of water, nutrients, algae and artificial light (. The heat provided by the syngas keeps the scrubber to the proper temperature where tars are condensed and algae can grow at proper rate. At the same time the CO_2 content in the gas can be, in part, converted into biomass by the algae. From the scrubber it is disposed a multi-phase liquid composed of water, biomass, tars and char. The first analysis carried out in this work consisted in a two phases process of the gas. First, in the gasification system, part of the gas was derived into a simple water scrubber where all the flows where measured and the temperature was kept constant at 30 °C. Then the water obtained in such a way was used as basis for algae grown in lab conditions. Results shown the capability of such a system to be used in existing gasification facilities.

A 10 kW gasifier power plant was used in this work [6]. It is an Imbert type downdraft gasifier fueled with wood chips. The syngas generated by the reactor is roughly filtered in a drum filter where wood chips are used by filter media. As depicted, part of the wood-gas is derived after the biofilter and it is sent the Water Algae Photo Bio Scrubber system (WAPBS): a series of 4 Drechsel bottles filled with about 0.4 l of syngas cleansing water (SCW). The syngas volume that pass through the bottles is measured by a gas meter. Into the bottles the syngas is cooled down from 50 °C to 30 °C, tar and particulate are trapped into the water while part of the CO_2 is available for the micro algae to be converted into biomass. The syngas flow through the bottles is very low (about 0.5 Nm^3/h), in such a way all the pollutants of the syngas are trapped into the bottles. Three tests was done increasing the volume of the syngas filtered in the bottles. Table III resumes the results in terms of condensate water, particulate and tar in each sample of scrubbing water.

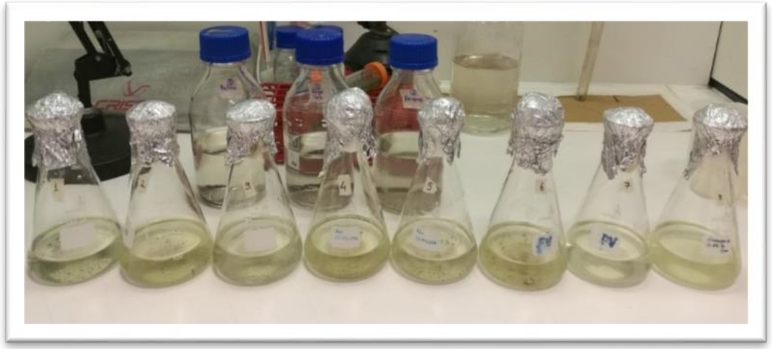
Experiment design | Tests | Results

24th European Biomass Conference and Exhibition, ETA-Florence Renewable Energies, Amsterdam, Netherlands, 2016

Biogas Digestate
Microbial Fuel Cell (MFC)

Microalgae Growth in Sewage Sludge Waste

Waste feedstock optimized in BEELab and IDRALab to provide microalgal cultivation and biomass yield



Cheese whey and olive waste

Agricultural Waste

Tomato Waste
Almond Skin
Grape waste

Arthrospira platensis = Spirulina platensis cultivation in different kinds of waste feedstocks

Chicken manure waste

Contents lists available at ScienceDirect
Bioresource Technology
journal homepage: www.elsevier.com/locate/biortech
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Combined effects of LED lights and chicken manure on *Neochloris oleoabundans* growth

Meltem Altunoz [a,d,f,*], Onofrio Pirrotta [b,c], Luca Forti [a,d], Giulio Allesina [e], Simone Pedrazzi [e], Olcay Obali [f], Paolo Tartarini [e], Laura Arru [a,d]

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[b] Dept. of Sciences and Methods for Engineering, University of Modena and Reggio Emilia, via G. Amendola 2 pad. Morselli, 42122 Reggio Emilia, Italy
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[d] Interdept. Research Centre Biogest-Siteia, University of Modena and Reggio Emilia, via G. Amendola 2 pad. Besta, 42122 Reggio Emilia, Italy
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[f] Dept. of Biology, Ankara University, Dögol Cad., 06100 Ankara, Turkey

HIGHLIGHTS

- Chicken manure is used as microalgal growth medium for *Neochloris oleoabundans*.
- Different wavelengths of LED such as white, blue and blue-red combined are tested.
- The basic design of a chicken-manure-fed photobioreactor is defined.

Solutions for cost effective energy use

Algal Growth Medium optimized by waste materials

+

Cost Effective Illumination Systems

Sizing of the illumination system for each wavelength

The optimal Energy flux for algae cultivation

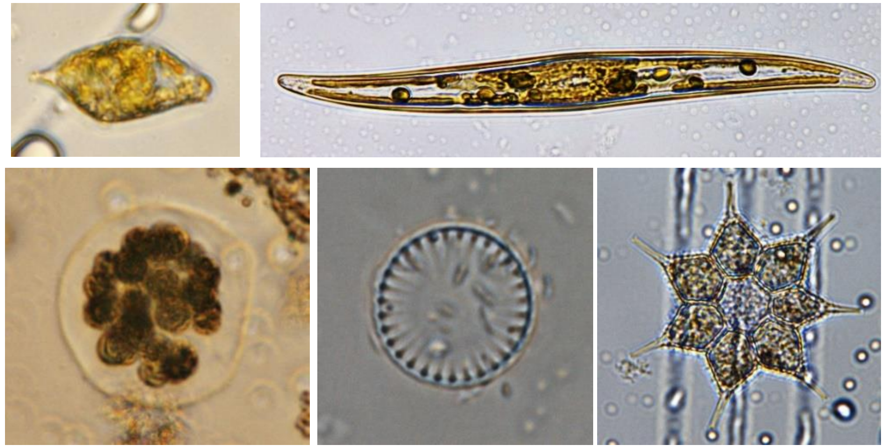
LED illumination systems Specific Wavelengths

Giulio Allesina, Simone Pedrazzi, Meltem Altunoz – 07-11-2017

Extreme habitats

Field surveys have been performed to understand natural behaviour of microalgal species

Secchia River Microalgae – Emilia Romagna



Regional field surveys have been organized to observe algal flora

✓ **Major Chemical Composition of different algae biomasses (% of dry matter)**

Algae	Protein	Carbonhydrate	Lipid
Chlorella vulgaris	**51-58**	**12-17**	**14-22**
Arthrospira platensis	**46-63**	**8-14**	**4-9**
Neochloris oleoabundans	**14**	**34**	**52**
Scenedesmus obliquus	50-56	10-17	12-14

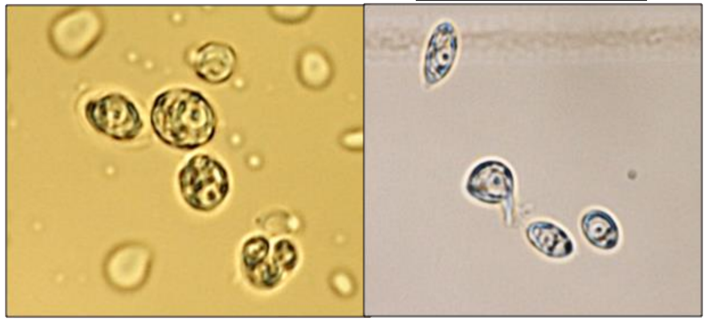
The Microalgal Species used due to the research/product aim

Microalgae growth in sewage sludge waste

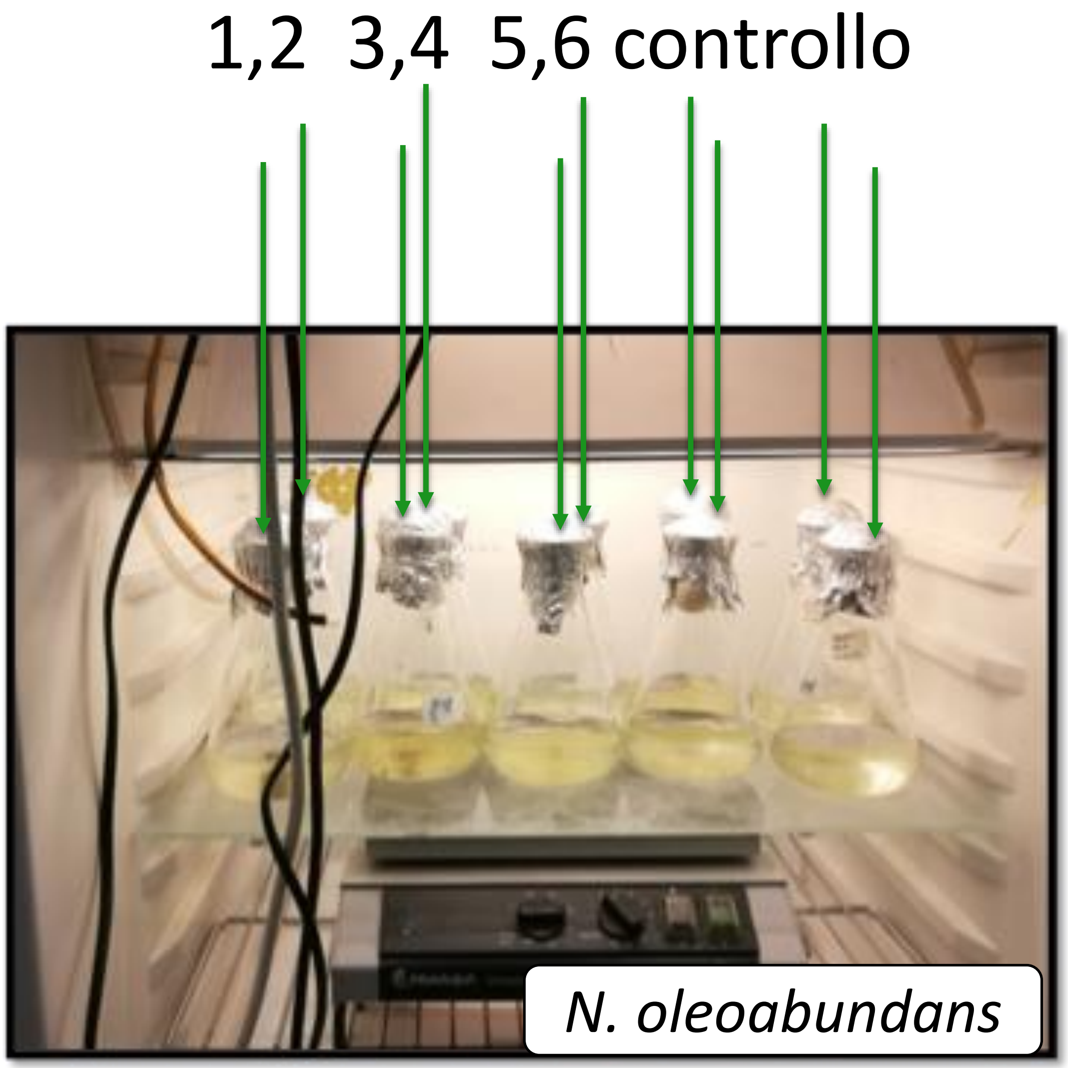
Sludge wastes
- Borgo Taro
- Fornovo
- Bedonia

Sludge waste → Feedstock for microalgae

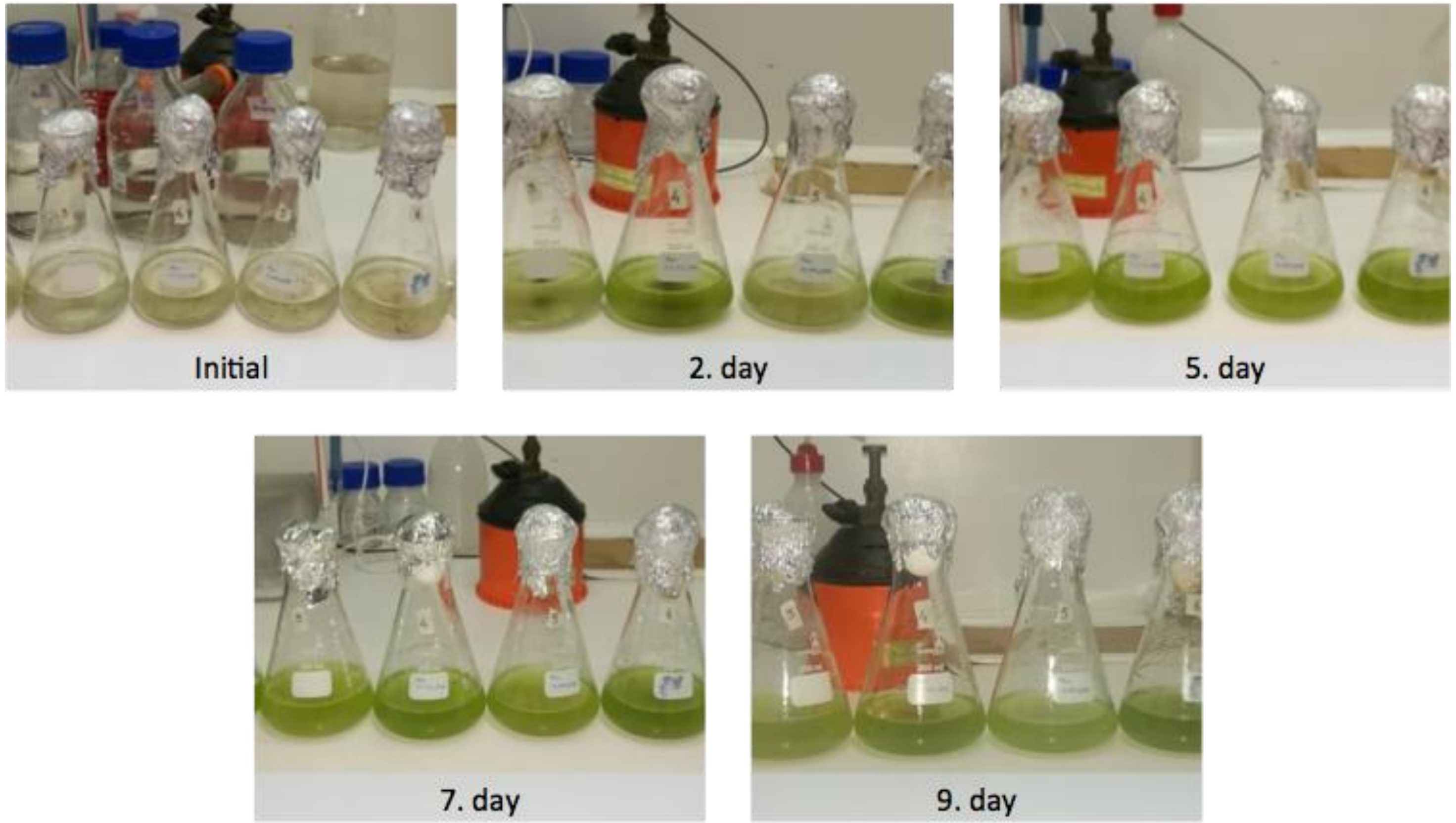
N. oleoabundans | *C. vulgaris*



Strain	Description
NB	*N. oleoabundans* in Bedonia Medium
NBT	*N. oleoabundans* in Borgo Taro Medium
NF	*N. oleoabundans* in Fornovo Medium
NBG11	*N. oleoabundans* in BG11 Medium
CB	*Chlorella sp.* in Bedonia Medium
CBT	*Chlorella sp.* in Borgo Taro Medium
CF	*Chlorella sp.* in Fornovo Medium
CBG11	*Chlorella sp.* in BG11 Medium



Microalgal growth within 9 days



Inoculation

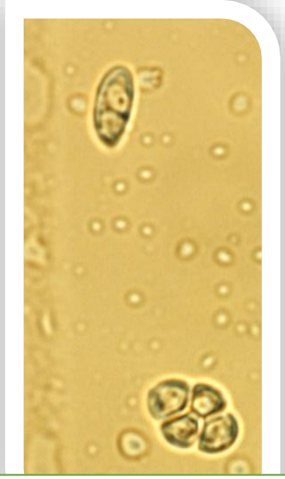
N. oleoabundans

$2x10^6$ cell/ml

C. vulgaris

$1x10^6$ cell/ml

The analysis both on *Chlorella vulgaris* and *Neochloris oleoabundans* to optimize the most efficient combination of the growth conditions



Neochloris oleoabundans

Growth Parameters

Cell Concentration

Optical Density

Growth Rate

Photosynthetic Pigment Content

Lipid Conctent

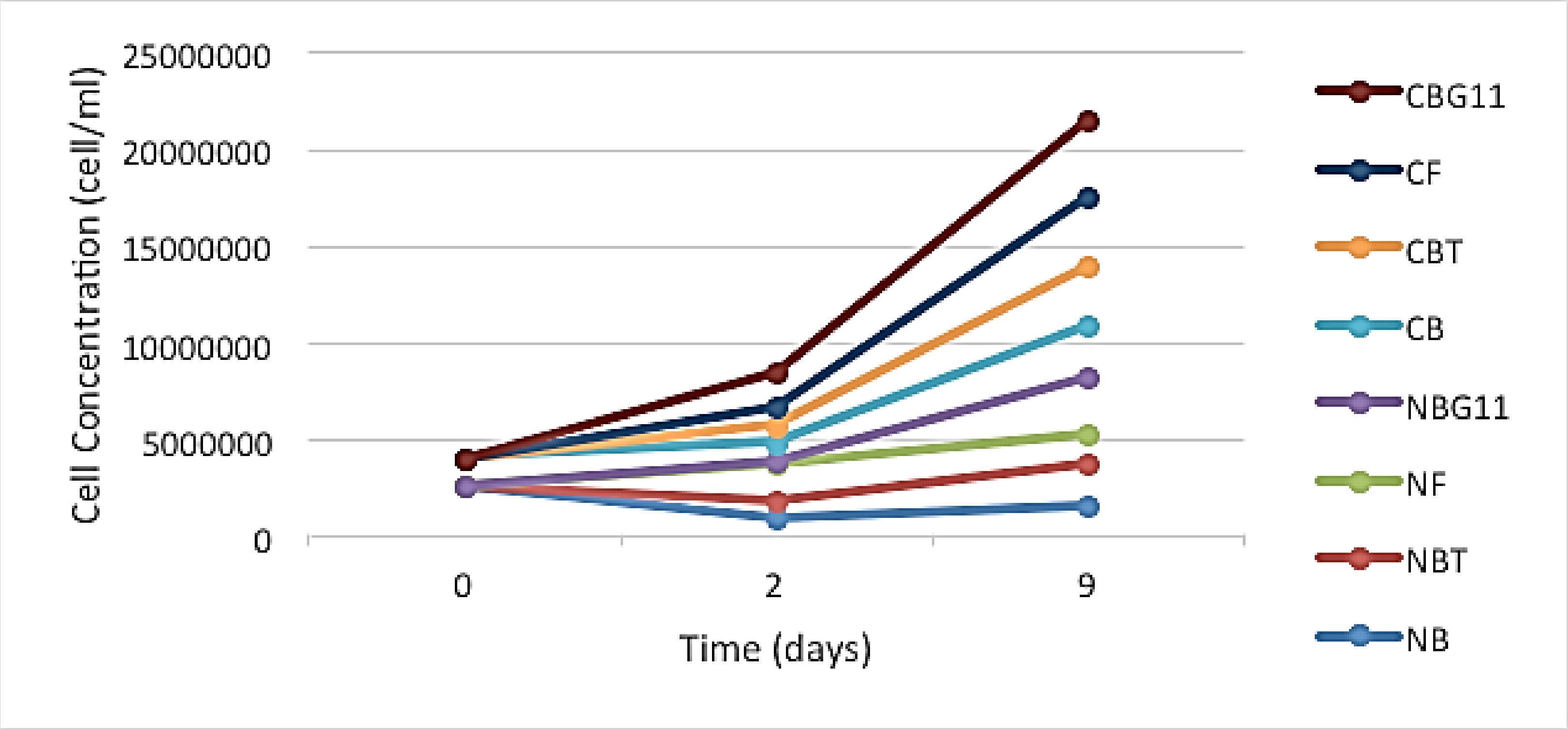
1st day

9st day

		Quantity of sludge used (g,ss/L)
Bedonia	*Chlorella sp.*	0,589
	N. oleoabundans	0,589
	Heterotrophic *N. oleoabundans*	0,589
Borgo Taro	*Chlorella sp.*	0,542
	N. oleoabundans	0,542
	Heterotrophic *N. oleoabundans*	0,542
Fornovo	*Chlorella sp.*	0,643
	N. oleoabundans	0,643
	Heterotrophic *N. oleoabundans*	0,643

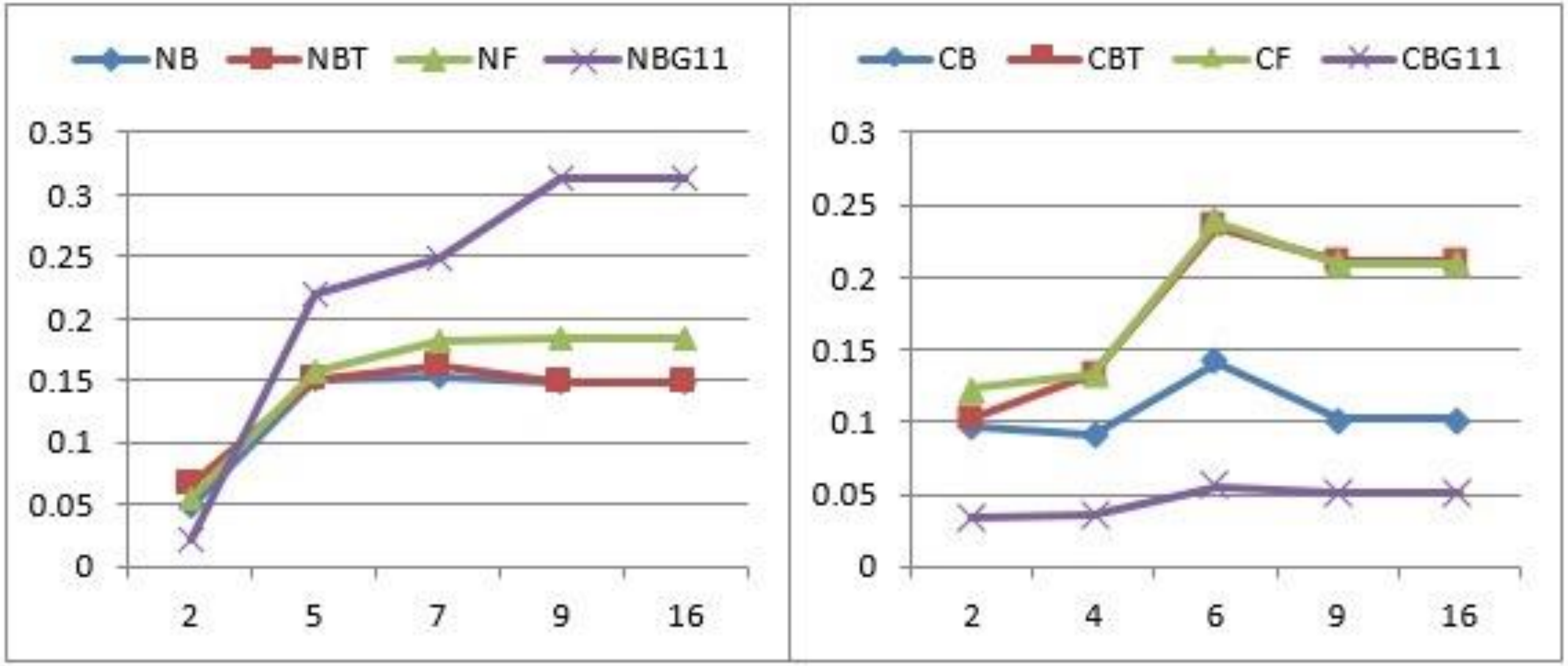
Sludge used in each optimized medium

Cell Concentration



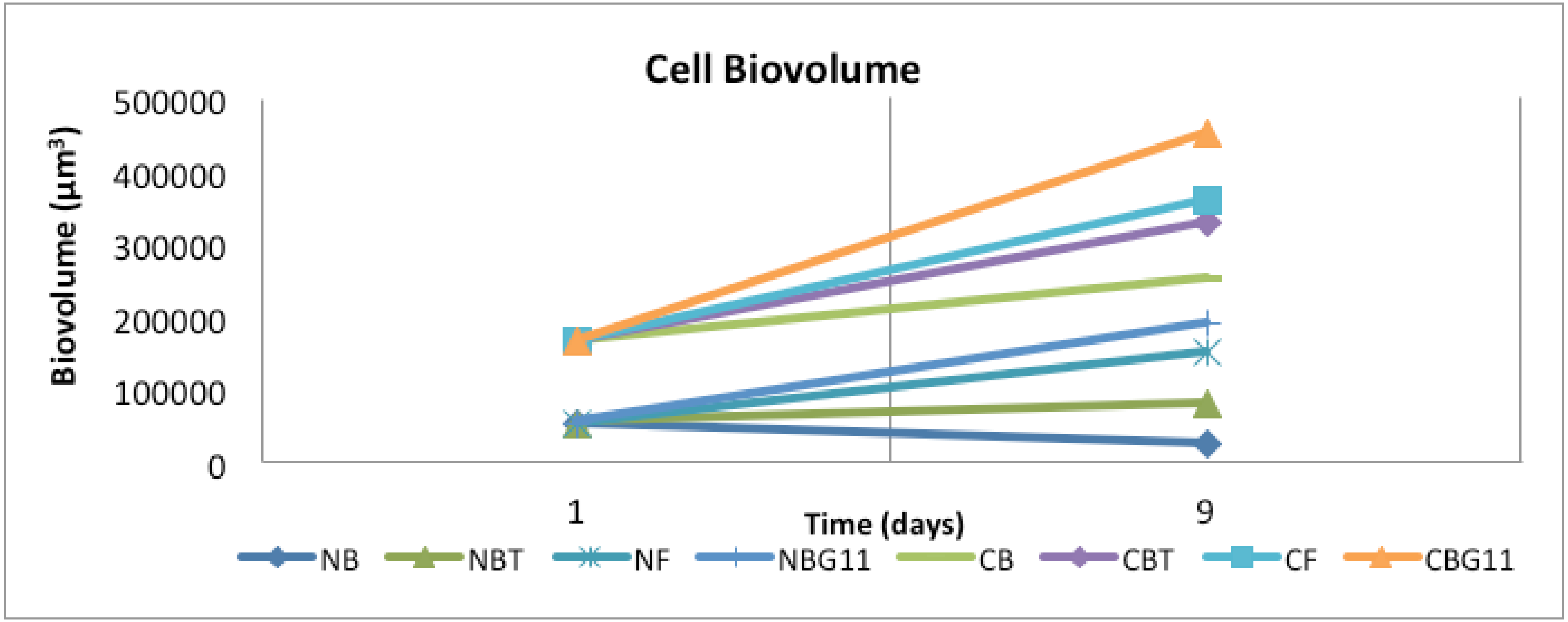
F: Fornovo BT: Borgo Taro B: Bedonia
BG11: Standard Medium

Optical Density



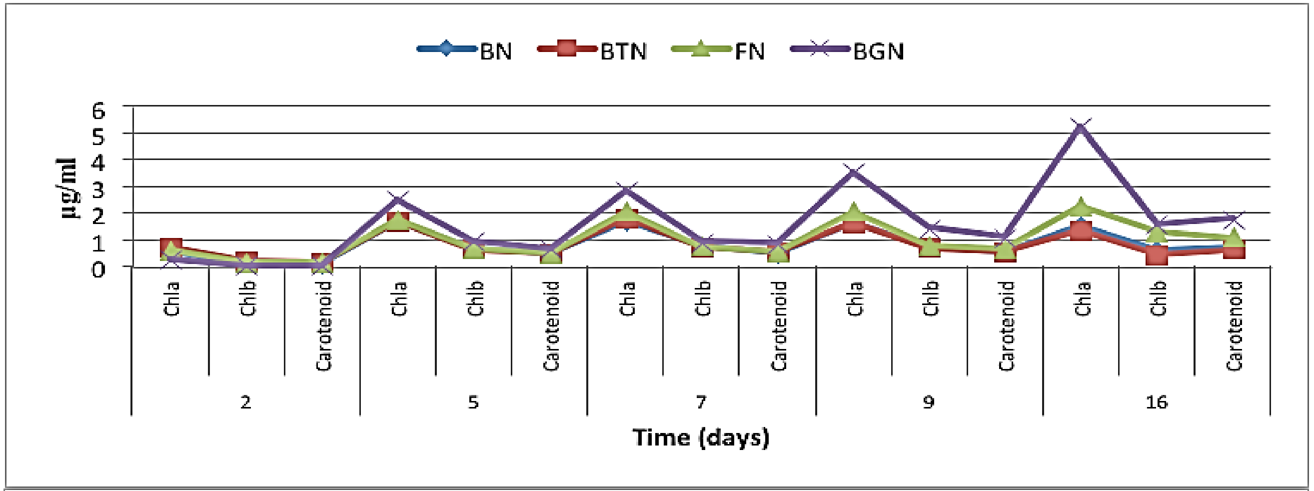
F: Fornovo BT: Borgo Taro B: Bedonia
BG11: Standard Medium

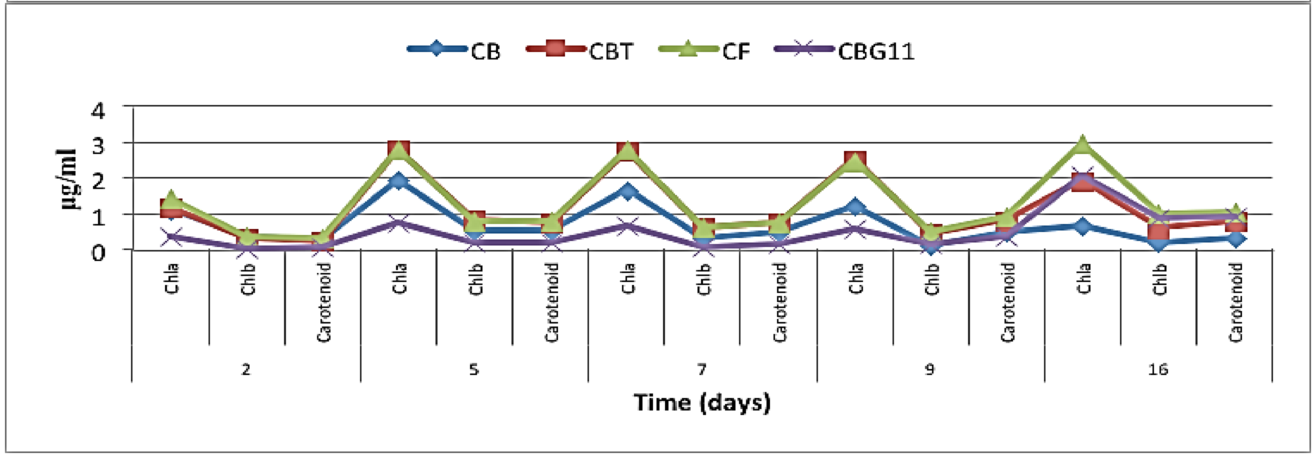
Cell biovolume



F: Fornovo BT: Borgo Taro B: Bedonia
BG11: Standard Medium

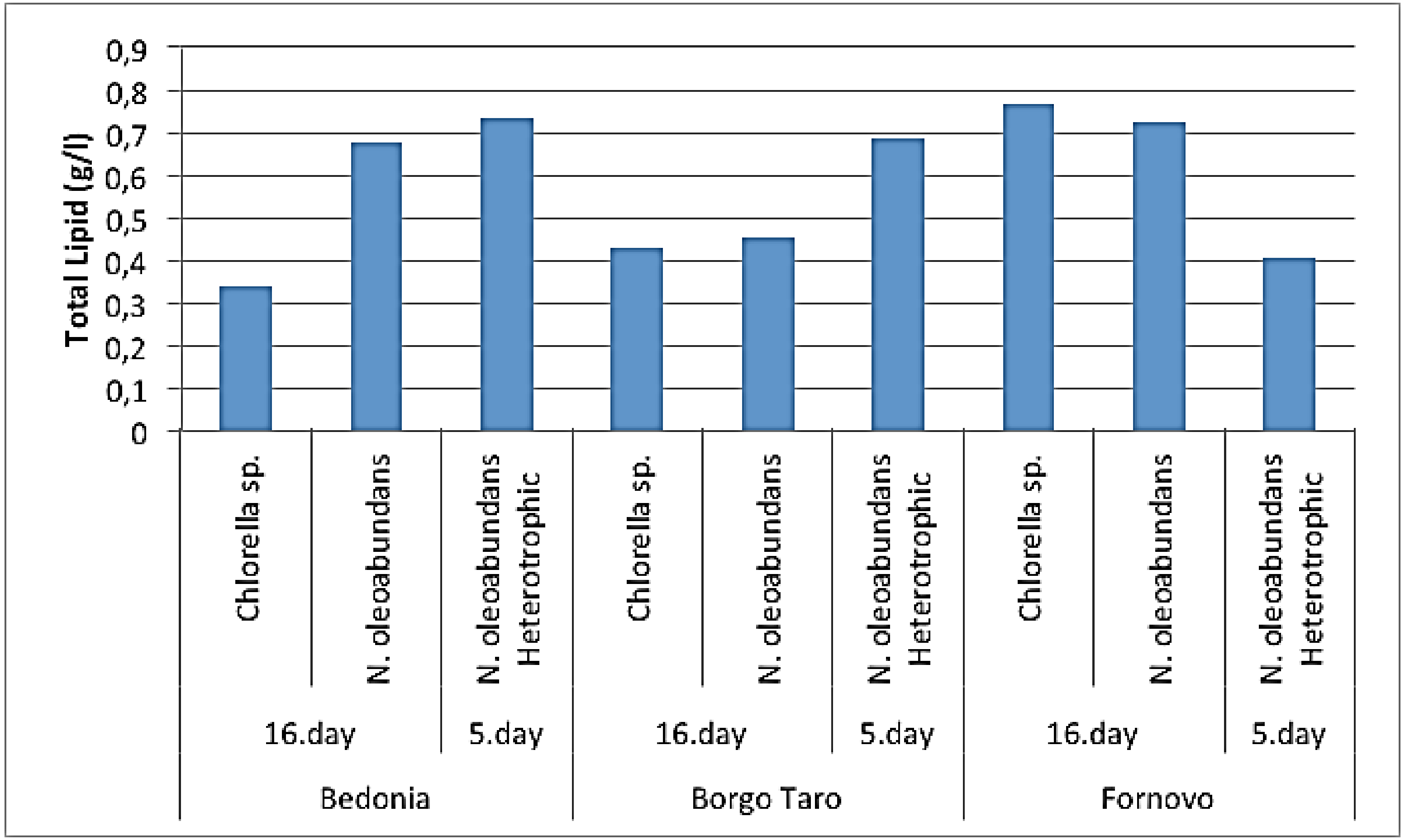
Photosynthetic pigment content (Chl a, Carotenoid, i. e. Astaxanthin)





F: Fornovo BT: Borgo Taro
B: Bedonia
BG11: Standard Medium

Total Lipid Content



Total Lipid Content

		Sludge (g)	Lipid content (g)	Quantitive sludge used (g,ss/L)
Bedonia	*Chlorella sp.*	1	0,339558574	0,589
	N. oleoabundans	1	0,679117148	0,589
	Heterotrophic N. oleoabundans	1	0,735710243	0,589
Borgo Taro	Chlorella sp.	1	0,430504305	0,542
	N. oleoabundans	1	0,455104551	0,542
	Heterotrophic N. oleoabundans	1	0,688806888	0,542
Fornovo	Chlorella sp.	1	0,76723691	0,643
	N. oleoabundans	1	0,725764645	0,643
	Heterotrophic N. oleoabundans	1	0,404354588	0,643

✓ PROTOTYPES

Microalgae fed by several types of waste materials

Water-Algae-Photo-Bio-Scrubber for Syngas Upgrading and Purification

24th European Biomass Conference and Exhibition
ETA-Florence Renewable Energies
Amsterdam, Netherlands, 2016

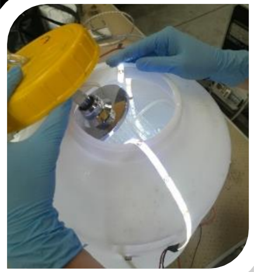
Prototype made by LEDs light sources -according to wavelength and light intensity need of the microalgae (*N.oleoabundans*)

Altunoz, M., Pirrotta, O., Forti, L., Allesina, G., Pedrazzi, S., Obali, O., . . . Arru, L. (2017). Combined effects of LED lights and chicken manure on Neochloris oleoabundans growth. *Bioresour Technol*

✓ PROTOTYPES

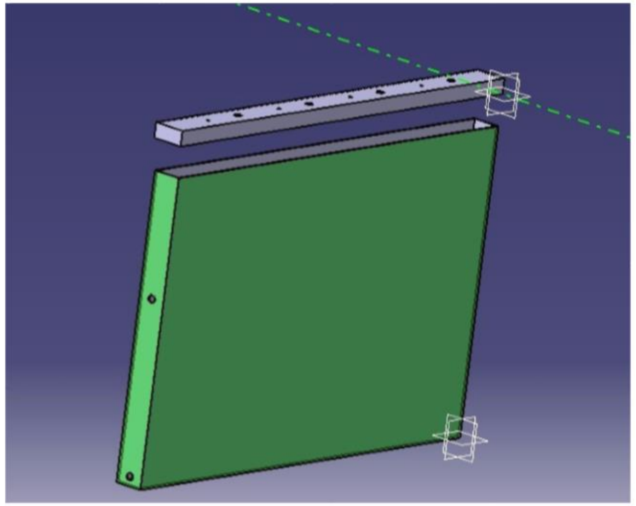
Microalgae fed by several types of waste materials

2 L Photobioreactor Prototype



20 L Photobioreactor Prototype

Photobioreactor prototype - with various wavelengths and intensities of illumination systems



100 L Flat Panel Photobioreactor Prototype

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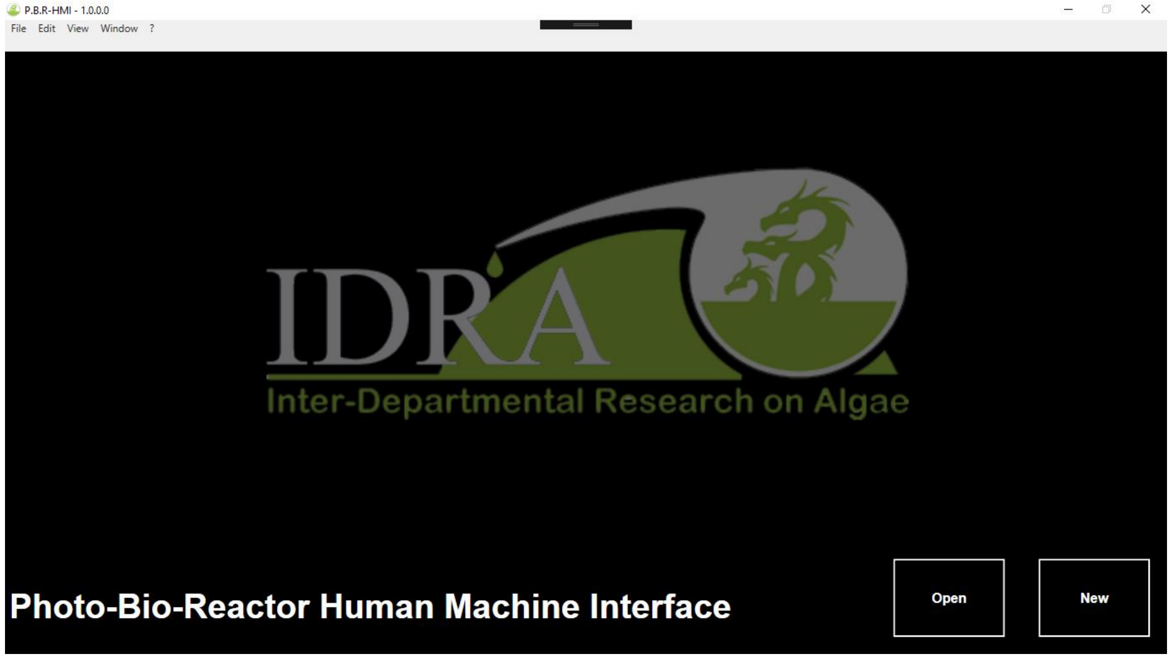
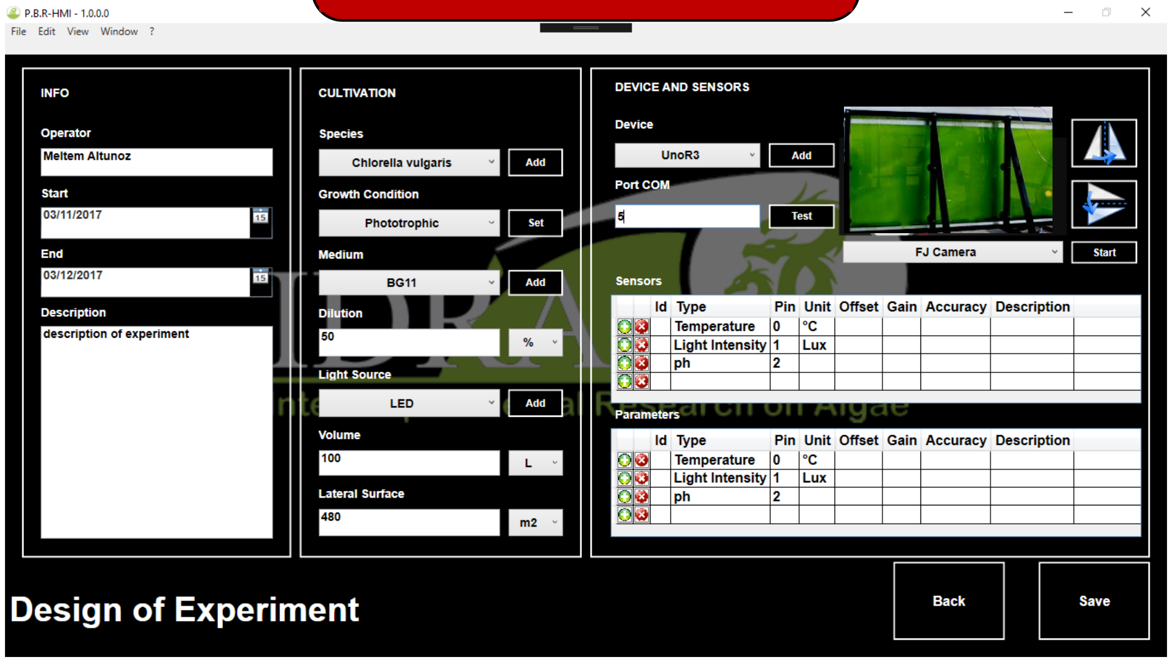
SOFTWARE

PHOTOBIOREACTOR HUMAN MACHINE INTERFACE



Experiments Database

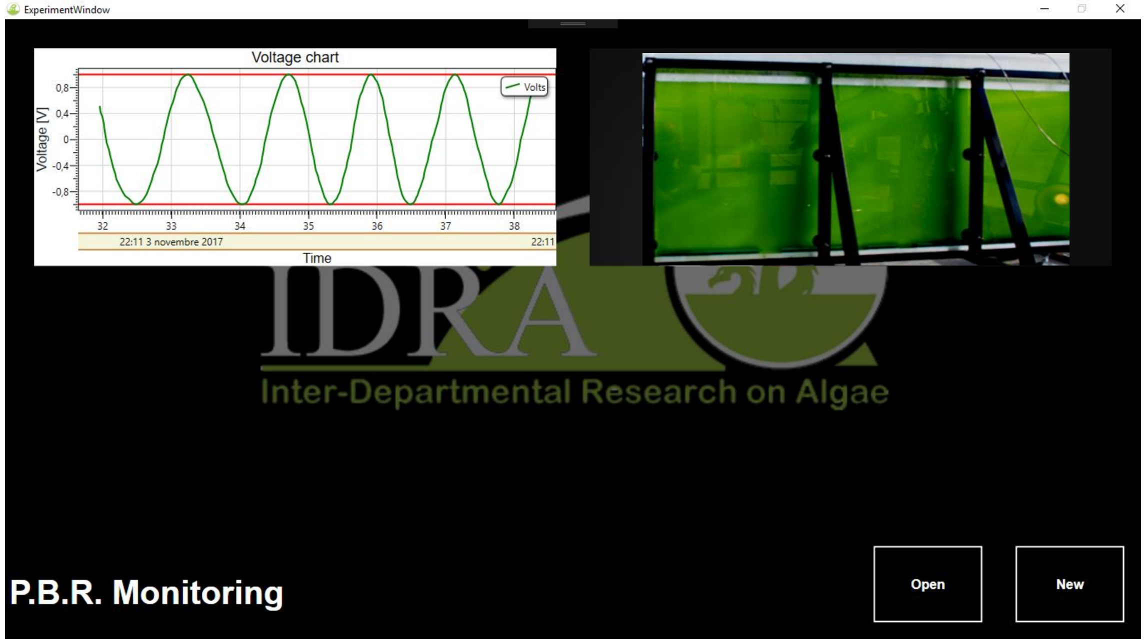
Automatic PBR parameters Control



SOFTWARE

PHOTOBIOREACTOR HUMAN MACHINE INTERFACE

Real Time PBR Monitoring



Easy Design of Experiment

Sensoors and Parameters Control

Giulio Allesina, Simone Pedrazzi, Meltem Altunoz – 07-11-2017

IDRALab

- Taxonomical identification list of algal species
- Axenic algae cultivation; New species isolation.
- Protocol adjustment for algal growth optimisation (lipid content, high protein added value for animal feed, etc.) in different mediums (from commercial standard to waste management/purification)
- Analysis of cell concentration, cell size, optical density, growth rate
- Analytical determination of chlorophyll a, chlorophyll b, carotenoids, total lipids, total carbohydrates, total solids and ashes
- Climate change investigation by monitoring algal flora distribution and abundance
- DNA/RNA isolation and analysis

Laboratorio Prof. Andrea Antonelli
Fractionation and analysis of pigments;
Total lipid content and fatty acid profile analysis;
Determination of the volatile component;
Determination of total nitrogen content and analysis of the amino acid component.

IDRA Culture Collection: *Neochloris oleoabundans, Spirulina platensis, Chlorella vulgaris, Gloeocapsa sp., Spirulina sp., Zygnema sp., Cladophora sp., Oedogonium sp.*

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BEELab, Dipartimento di Ingegneria "Enzo Ferrari"

Laboratorio BEELab

The Bio-Energy Efficiency Laboratory -BEELab, is part of the Engineering Department "Enzo Ferrari" of the University of Modena and Reggio Emilia. BEELab is the result of the experience and knowledge gained throughout the years by the research group of Technical Physics in the field of renewable energies and thermo-fluidodynamics measures. BEELab offers a wide range of services to supporting researches mainly focused on the development of advanced and innovative solutions for bio-energy efficiency

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THANK YOU

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