Integrated Algae Pond Systems (IAPS) for Waste Water Treatment and Beneficiation

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OVERVIEW & CONTENTS

- Why algae-based waste water treatment?
- Opportunities in waste water treatment biotechnology
- The EBRU Integrated Algae Pond System
- The EBRU IAPS process flow
- Advanced Integrated Wastewater Pond Systems (AIWPS)
- Demonstrating sustainable renewable energy supply
- Sustainable organic fertilizers, high-value and commodity products
- Concluding comments
- Q & A

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PONDS AND ALGAE-BASED WASTE WATER TREATMENT SYSTEMS

"*The greatest advantages of ponds are their simplicity, economy, and reliability; their greatest drawbacks are their high land use, their potential for odor, and their tendency to eutrophy and fill in with sludge and to become less effective with age.*" (Oswald 1990)

"*Based on operational simplicity, low cost and high removal efficiencies (99% BOD_5, suspended solids and coliform bacteria removal), AIWPS is highly recommended for up to 1000 mg/L BOD_5 concentration. Because of its high coliform bacteria removal efficiency, the effluent of AIWPS may be used for irrigation purposes.*" (Ertas and Ponce 2012)

"*when properly designed in appropriate locations, the systems virtually eliminate sludge disposal, minimize power use, require less land than conventional ponds, and are much more reliable and economical than mechanical systems of equal capacity*" (Oswald 1990)

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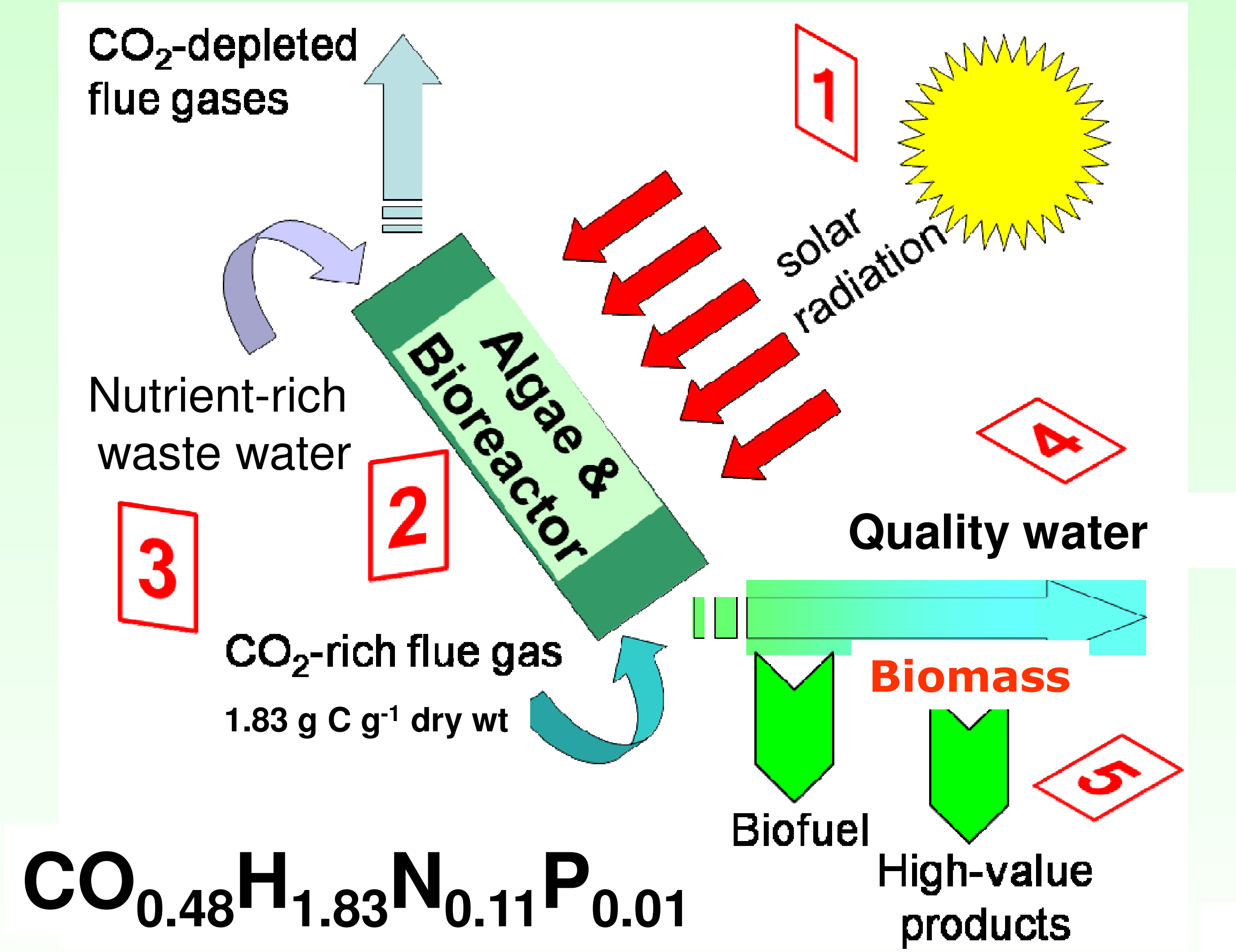
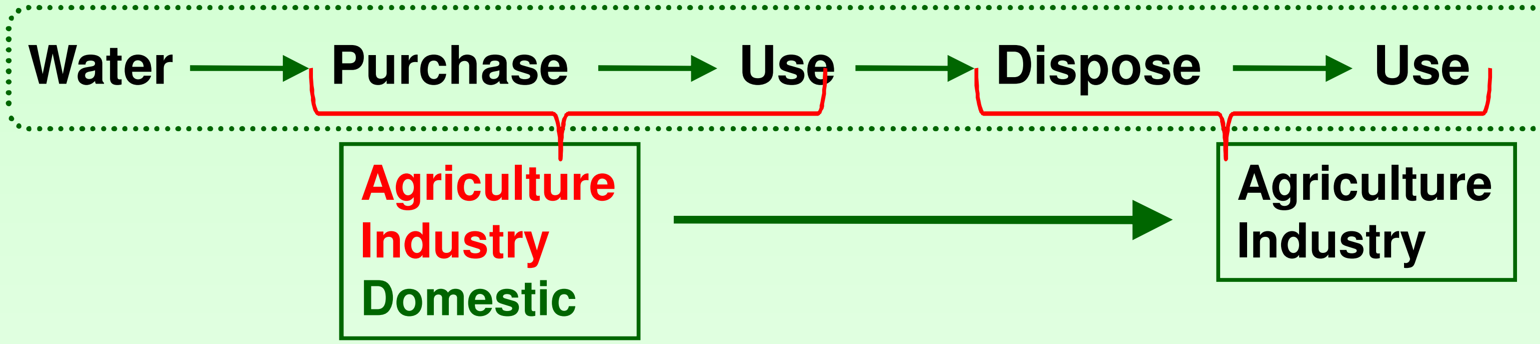
BASIC CONCEPT OF AN ALGAE-BASED WASTE WATER BIOPROCESS SYSTEM



OPPORTUNITIES IN WASTE WATER BIOTECHNOLOGY



- Sustainable clean, valorised water
- Sustainable biomass production
- Agriculture & horticulture
- Biofuels – oils for biodiesel; biomass for biogas
- Commodity chemicals
- Fine chemicals
- Opportunity for discovery

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THE EBRU INTEGRATED ALGAE POND SYSTEM

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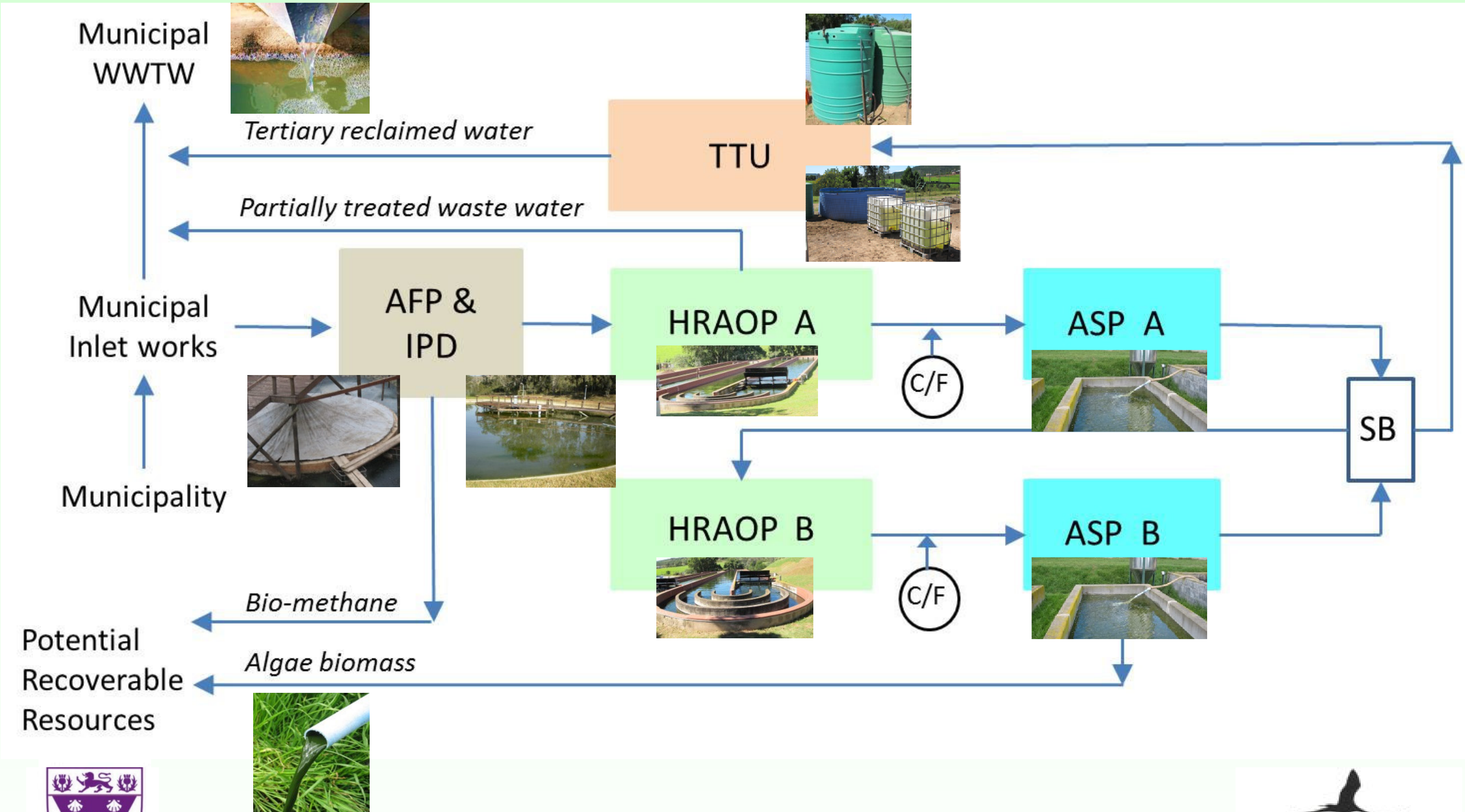
THE EBRU INTEGRATED ALGAE POND SYSTEM (IAPS): PROCESS FLOW



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IAPS PROCESS BIOCHEMISTRY AND METABOLISM

Algae in the aerobic layer of the **Advanced Facultative Pond (AFP)** release oxygen while aerobic microorganisms utilize this oxygen to break down organic compounds to generate CO_2 which is used by the algae and this biochemistry can be summarized as follows;

Photosynthesis: $CO_2 + H_2O \leftrightarrow CH_2O + O_2$

Aerobic oxidation: $CH_2O + O_2 \leftrightarrow CO_2 + H_2O$

Organic acid formation: $2CH_2O \leftrightarrow CH_3COOH$

Methanogenesis: $CH_3COOH \leftrightarrow CH_4 + CO_2$

$CO_2 + 4H_2 \leftrightarrow CH_4 + 2H_2$

Heterotrophic nitrification: Fixed N $\leftrightarrow NO_3^-$

De-nitrification: $2NO_3^- + 3CH_2O \leftrightarrow N_2 + 3CO_2 + 3H_2O$

75-80% Reduction in COD

In the **High Rate Algae Oxidation Ponds** the major reactions increase dissolved oxygen concentration to super saturation at 20 mg L^{-1} and this coupled with high pH (>10) and light disinfects the effluent;

Photosynthesis: $CO_2 + H_2O \leftrightarrow CH_2O + O_2$

Nitrate assimilation: $NO_3^- + 2H^+ + 2e^- \leftrightarrow NO_2^- + H_2O$

$NO_2^- + 7H^+ + 6e^- \leftrightarrow NH_3 + H_2O$

Aerobic oxidation: $CH_2O + O_2 \leftrightarrow CO_2 + H_2O$

10-15% Reduction in COD

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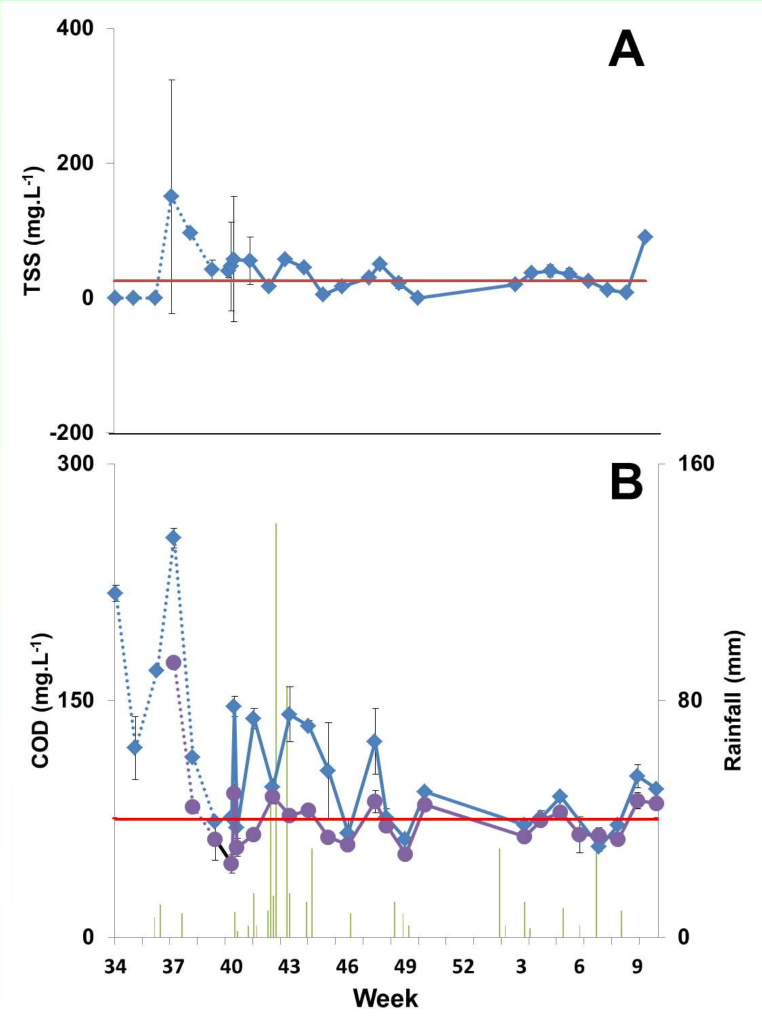
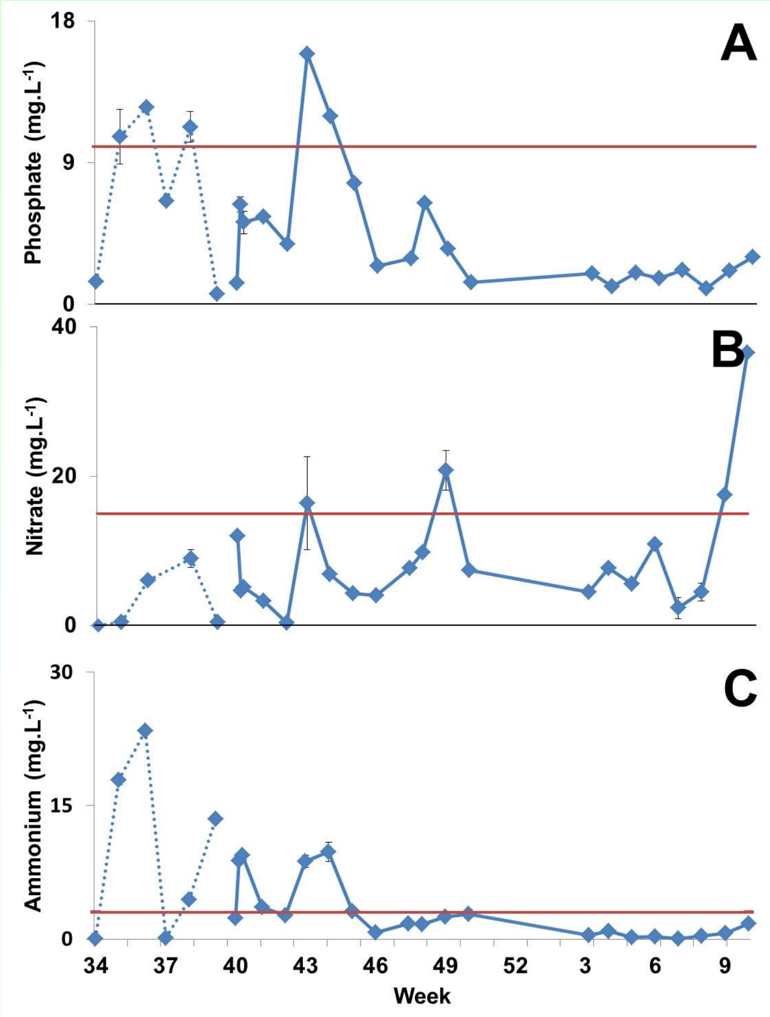
THE EBRU INTEGRATED ALGAE POND SYSTEM: EFFICIENCY AND COMPLIANCE





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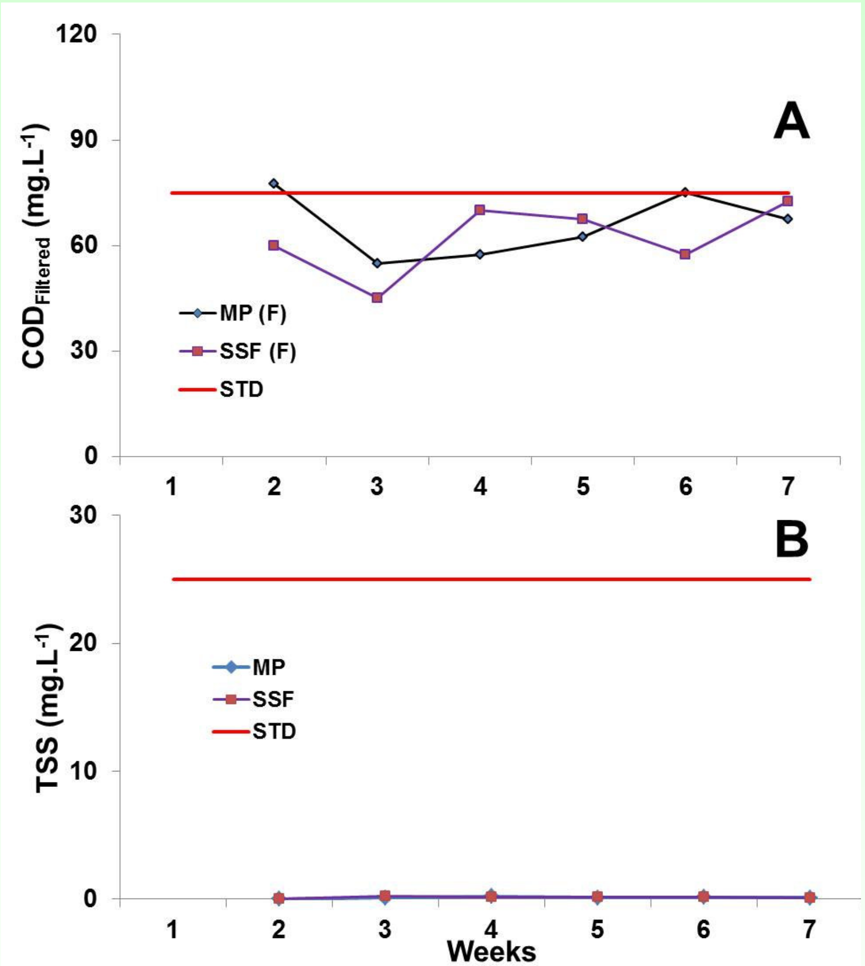
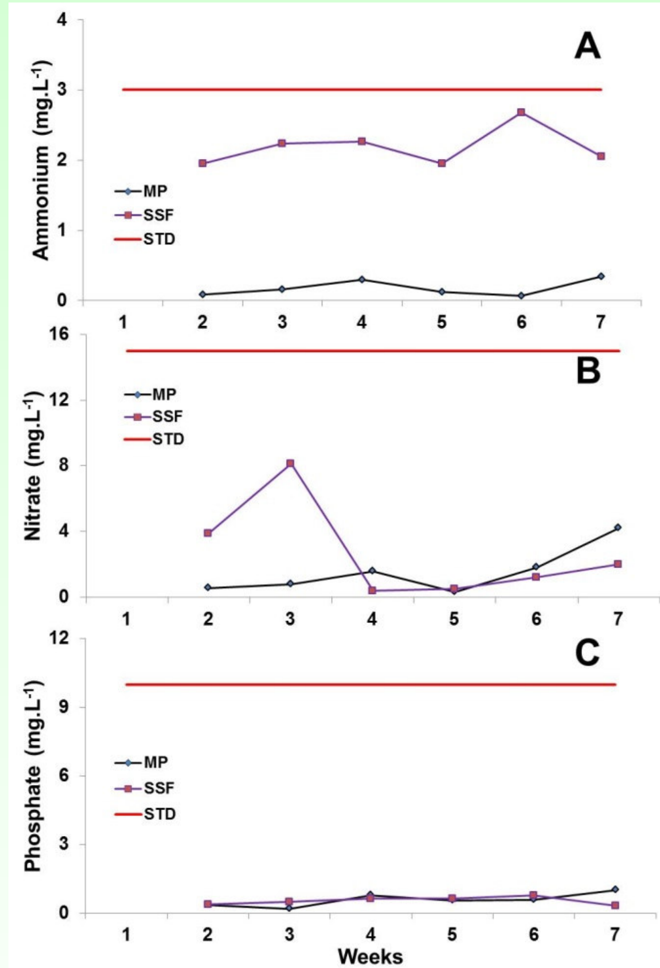
THE EBRU INTEGRATED ALGAE POND SYSTEM: EFFICIENCY AND COMPLIANCE POST 'TTU'





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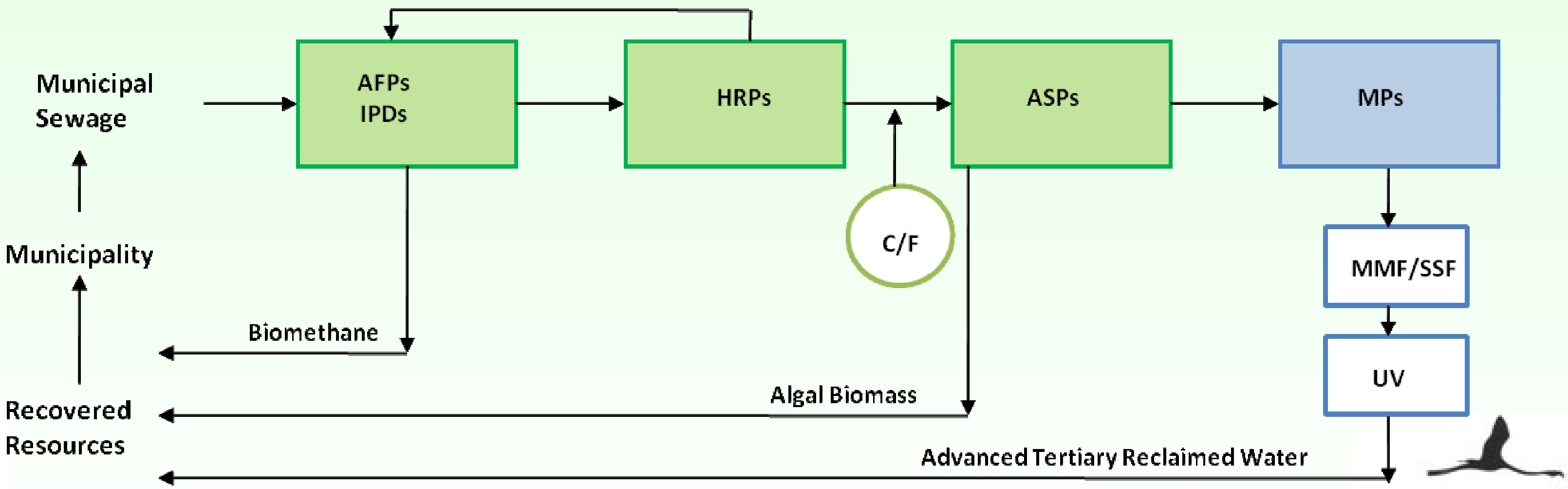
ADVANCED INTEGRATED WASTEWATER POND SYSTEMS (AIWPS®)

AIWPS® Advanced Tertiary Process Schematic



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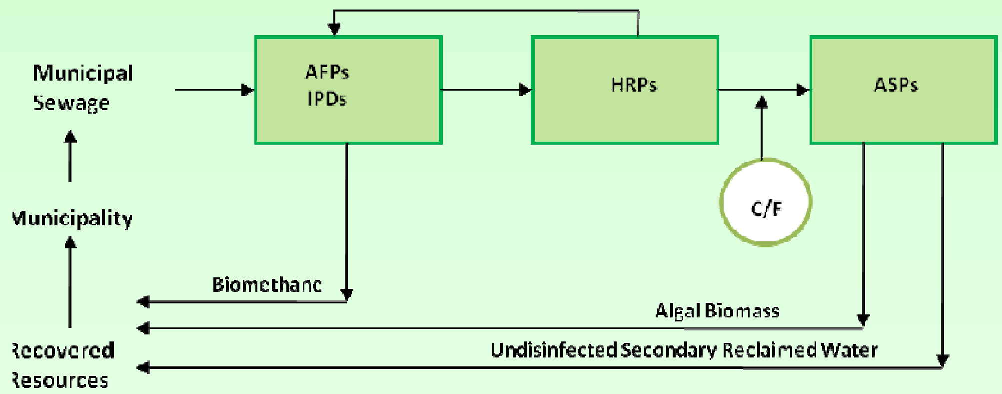
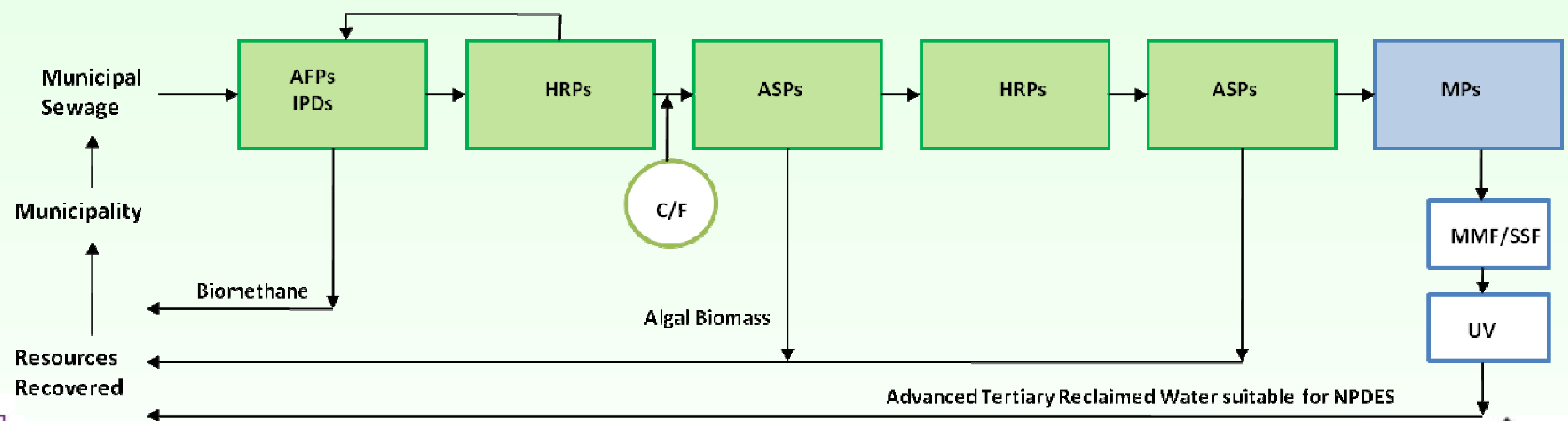
AIWPS® DESIGN AND OPERATING CONFIGURATION

AIWPS® Secondary Process Schematic



AIWPS® Advanced Tertiary Process Schematic for Nutrient Removal



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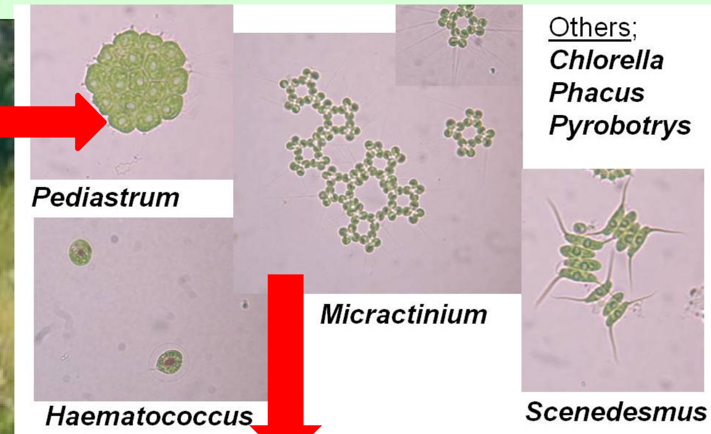
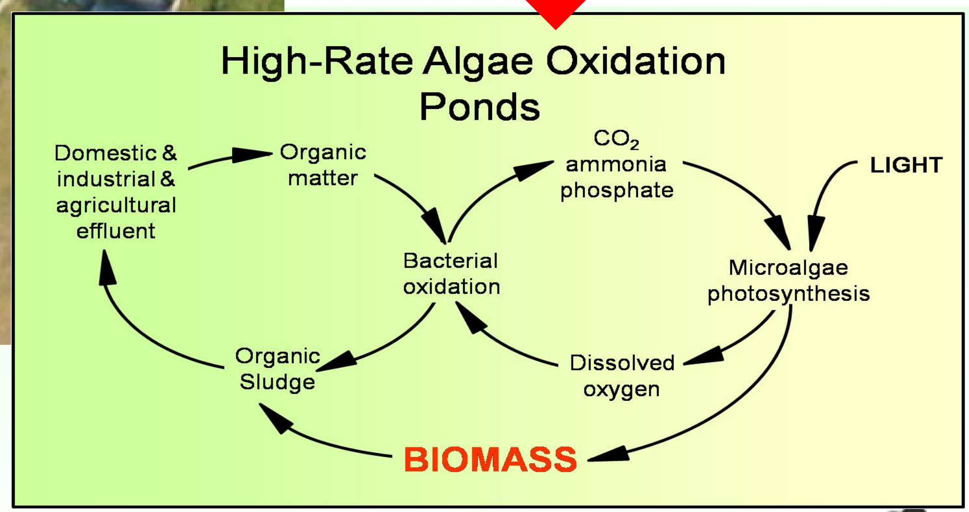
THE EBRU INTEGRATED ALGAE POND SYSTEM: CLEAN WATER, SUSTAINABLE BIOGAS AND BIOMASS





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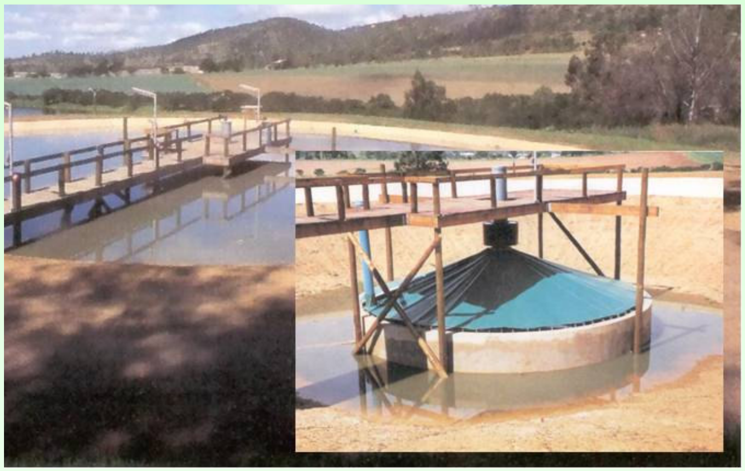
METHANE PRODUCTION FROM THE IN-POND IAPS DIGESTER



Production rate (m^3)	IAPS
CH_4/kg BOD_5	0.15
CH_4/kg BOD_{ULT}	0.24
CH_4/day (400 PE)	7.68
CH_4/day (500 PE)	9.60
CH_4/day (600 PE)	11.52
Biogas at 86% CH_4, then totals are m^3 biogas/day (500 PE)	11.16

160 GJ OR 44 megawatt-hour per year

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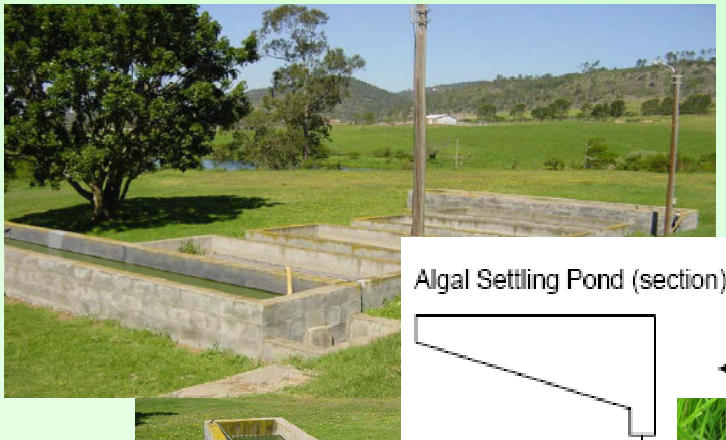
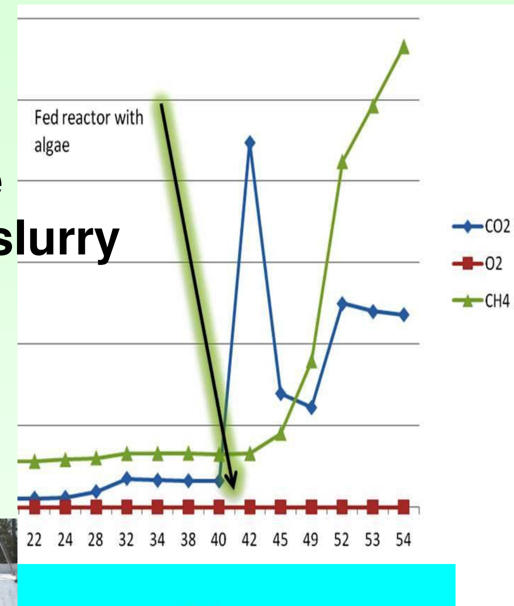
HARVESTING AND DIGESTING IAPS ALGAE BIOMASS TO METHANE



Wet algae biomass slurry



Biogas

Net energy yield
CH_4 = 9.98 $GJ.d^{-1}$
(at steady state)

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INTEGRATION INTO BELMONT VALLEY, A 5 ML PER DAY WASTE WATER TREATMENT PLANT

Bio-energy available	
Bio-methane	***m^3***
Bio-methane from 5 ML per day WWTP	1,020,689
Bio-methane from the IAPS	16,653
Total bio-methane from 5 ML WWTP	1,037,342
Liquid fuel equiv	***Litres***
Petrol @ 0.861 L per m^3 CH_4	893,151
Diesel @ 0.686 L per m^3 CH_4	711,616
Heating/cooking gas equiv	***kg***
LPG @ 0.714 kg per m^3 CH_4	740,662

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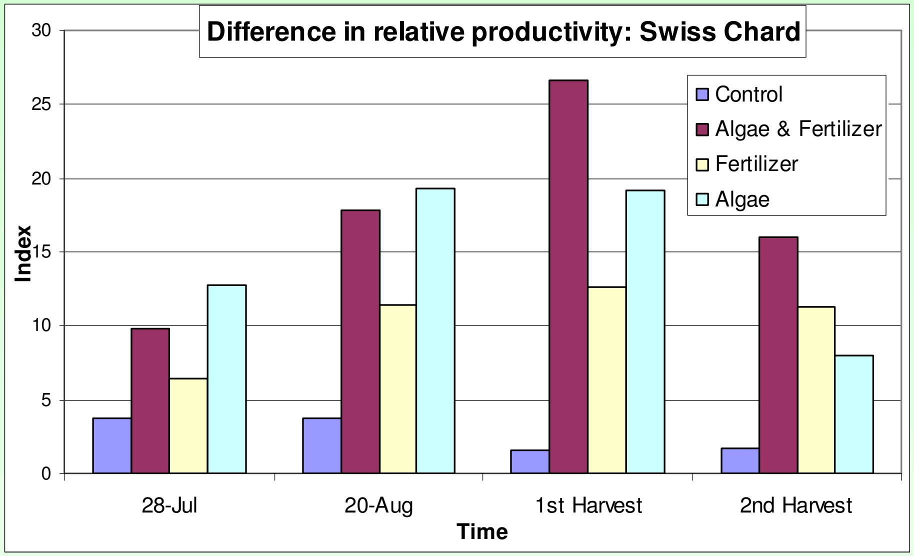
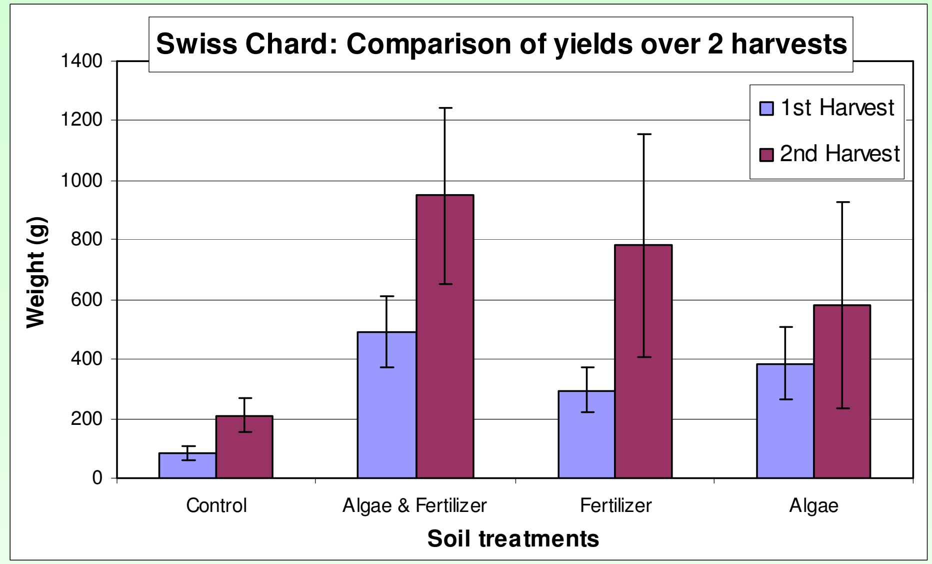
MICROALGAE BIOMASS AS ORGANIC FERTILIZER





Control Algae and Fertilizer Fertilizer Algae

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MICROALGAE BIOMASS AS ORGANIC FERTILIZER

Control Algae and Fertilizer Fertilizer Algae

Fertilizer Algae Algae and Fertilizer

Control Algae and Fertilizer Fertilizer Algae

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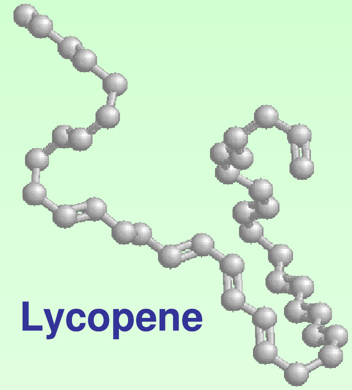
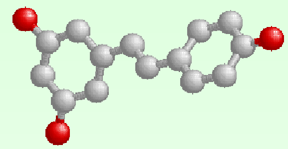
MICROALGAE BIOMASS FOR HIGH-VALUE PRODUCTS

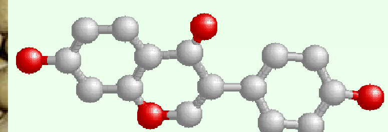
Carotenoids (>700)	Cancer; cardiovascular disease	
Phenolics (>4000)	Cancer; cardiovascular disease	
Phyto-estrogens (>200)	Cancer; steoporosis; Cardiovascular disease	
Glucosinolates (>100)	Cancer	



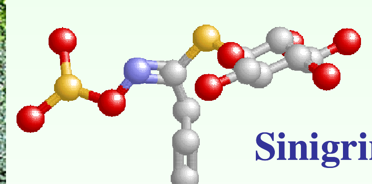
Lycopene



Resveratrol



Genistein



Sinigrin

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MICROALGAE BIOMASS FOR COMMODITY PRODUCTS

Algae paste	
High protein powder	
Lecithin	

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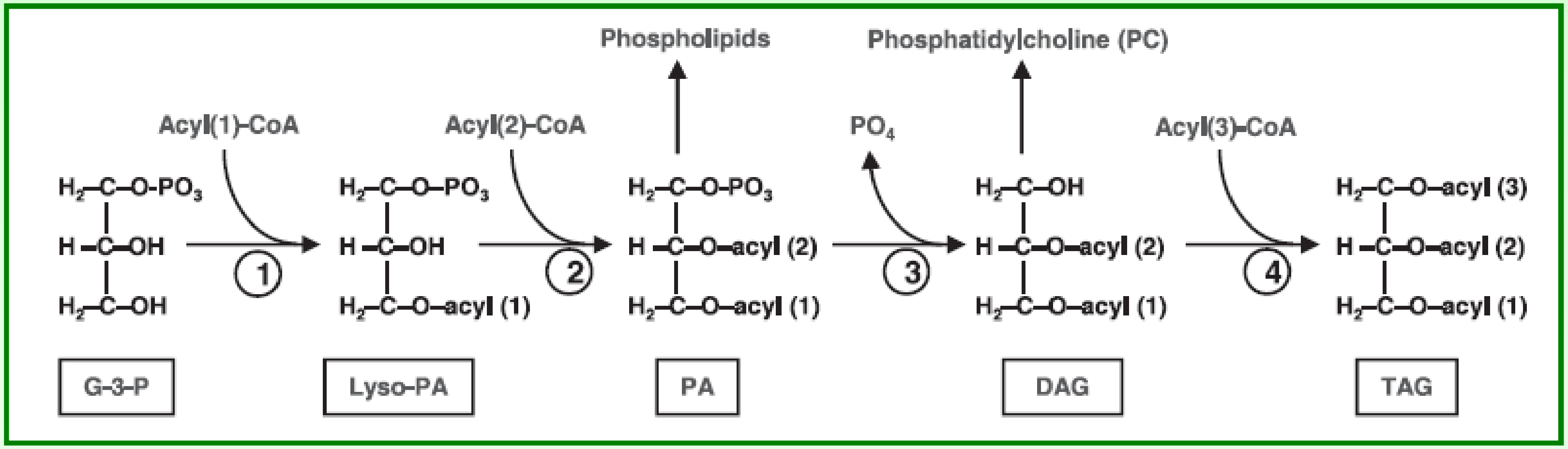
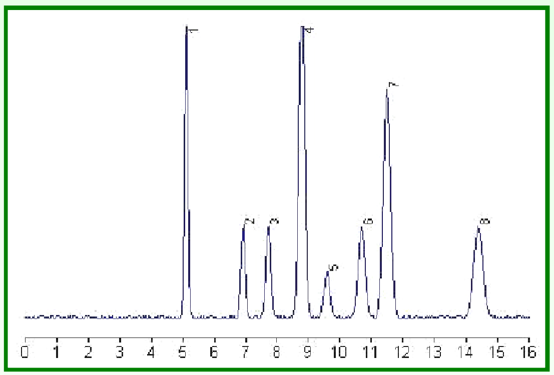
MICROALGAE PHOSPHOLIPIDS AND LECITHIN AS A COMMODITY PRODUCT





Species	PL species	% of total lipid	Fatty acids
Micractinium	PC, PE, PG	36	C18:2; C16:0; C18:3; C16:3; C16:1; C16:4
Pediastrum	PC, PE, PG	40	
Scenedesmus	PC, PE, PG	41	
Clorella	PC, PE, PG, PI	42	
Haematococcus	PC, PE, PG	28	
Dunaliella	PC, PE, PG	20	

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CONCLUDING COMMENTS: FUTURE OF ALGAE-BASED WASTE WATER TREATMENT SYSTEMS

- Passive, solar powered waste water treatment system ideal for small towns and decentralised use
- Less than 10% of the energy produced by an IAPS bioprocess system is needed by the system
- Can augment larger plants a supply biomass for optimum anaerobic digestion and bio-methane production
- Can be operated as stand-alone water-treatment and energy producing systems – domestic and industrial waste
- Produces a substantial biomass to be valorized into a number of products – low and high-value and sustainable
- Provides platform for peripheral biotech industries, employment opportunity, additional revenue streams, and community and regional independence

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THANK YOU

Q & A

EBRU acknowledges financial support from:

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