SaltGae

algae to treat saline wastewater

Final meeting
24-25 September 2019
Ljubljana, Slovenia

Arava demo site Israel

S. Penno-Winters, Y. Kohn

H2020-Water-1b-2015

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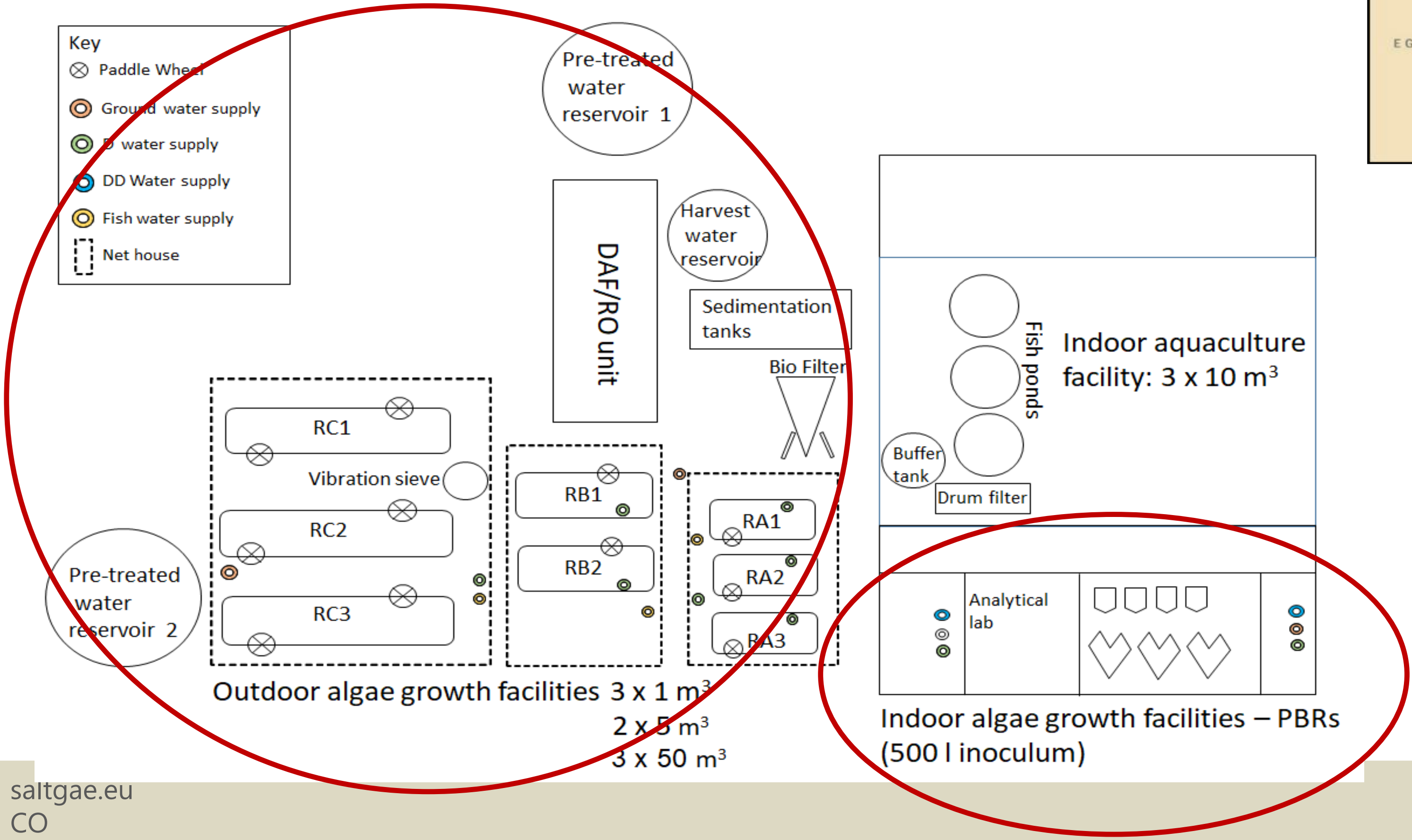
Arava demo site – system design

Location: Agricultural R&D institute in the Arava, Southern Israel within an arid desert area

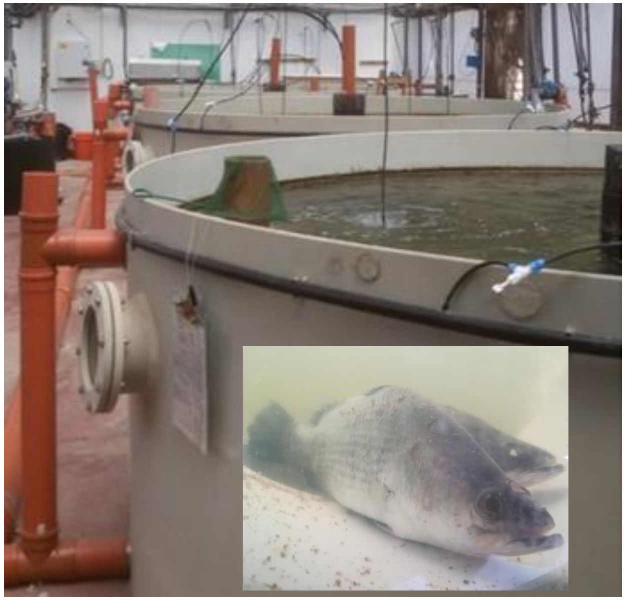
Objective: establishment of large scale HRAP treating low BOD content, low salinity aquaculture wastewater while producing algae biomass



Arava demo site – system design

System components:

	Capacity	Biomass production	Species	Operation mode
Indoor aquaculture	30 m^3	2 ton/year	*Lates calcarifer* (Barramundi)	continuous
Indoor algae PBRs	0.5 m^3	Algae inoculum	Spirulina	continuous
Outdoor algae HRAPs	163 m^3	300 kg DW/month	Spirulina	batch/continuous



Arava demo site – system design

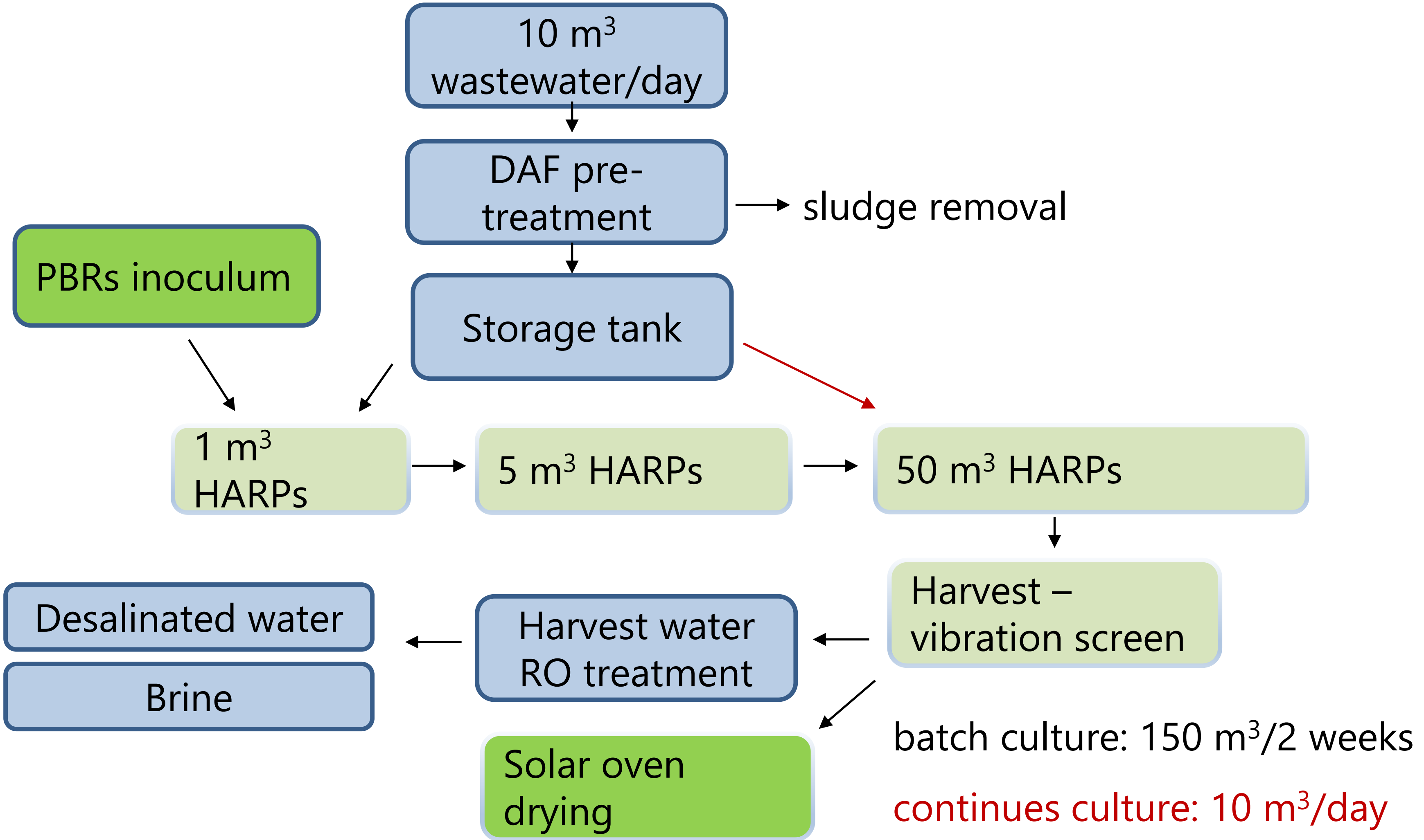
SaltGae technology employed:

- Wastewater pre-treatment - DAF – BiboAqua
- System monitoring – Sensors- Sensors – Oxidine
- Harvest water recovery – RO - BiboAqua

SaltGae partners cooperation: PTP, Extractis, RISE, Archimede, Algen/KOTO

Arava demo site – system design

- Full system continuous operation since June 2019 on wastewater



- Regular water input for: PBRs, evaporation compensation (4%), wash at harvest (5 %)

Algae cultivation

	Batch culture	Continuous culture
Wastewater treatment	10 m^3/day	10 m^3/day
Algae production	150 kg DW/2 weeks	10 kg DW/day
Energy consumption (RISE)		20 -30 % lower
Fresh water consumption (RISE)		60 % higher

Monitoring of algae system

Lab monitoring

- Regular (every 2-3 days) in house

✓ pH, conductivity, temperature
✓ Phosphate, nitrate, ammonium
✓ Algae biomass
✓ Microscopy (weekly)

- Outsourced analysis of BOD, COD, TSS, TOC, micronutrients and others

Automatized monitoring (sensors – Oxidine)

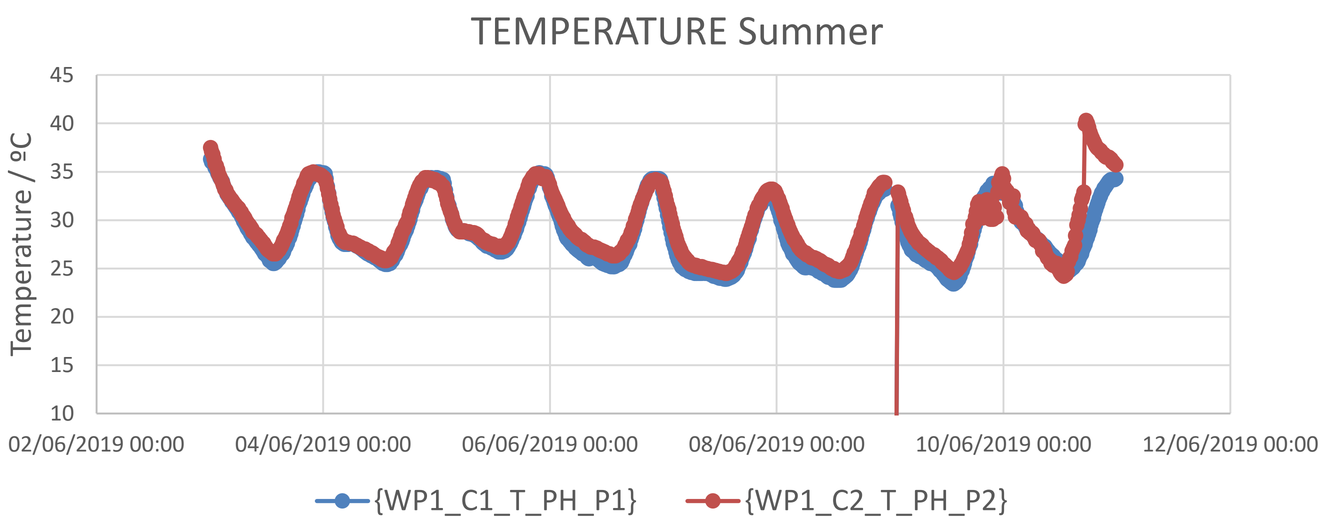
- pH, conductivity, **temperature, Chl*a*, light (PAR),** NO_3

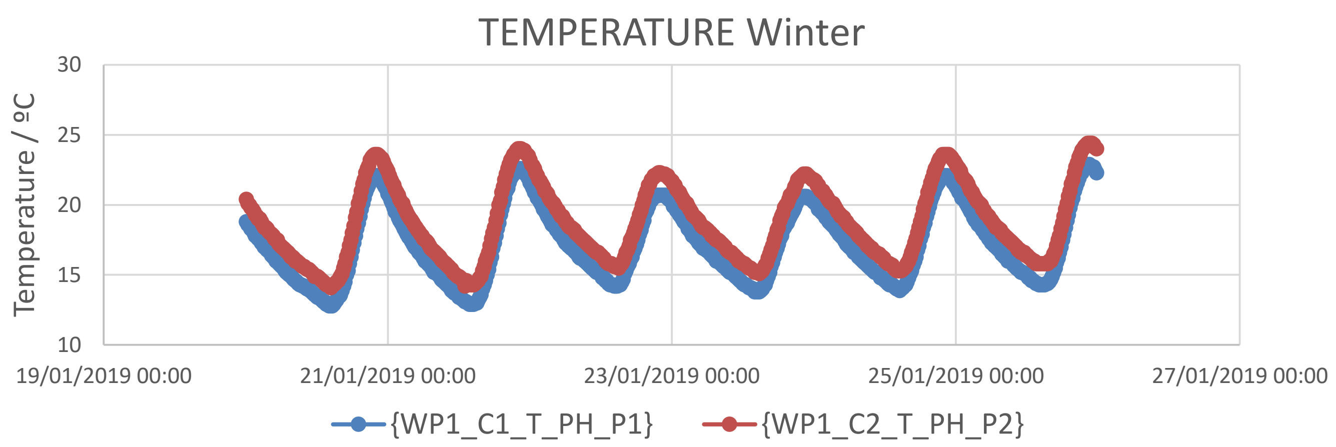
- easy and quick display, range limitations

- maintenance crucial (cleaning, calibration), risk of false reading

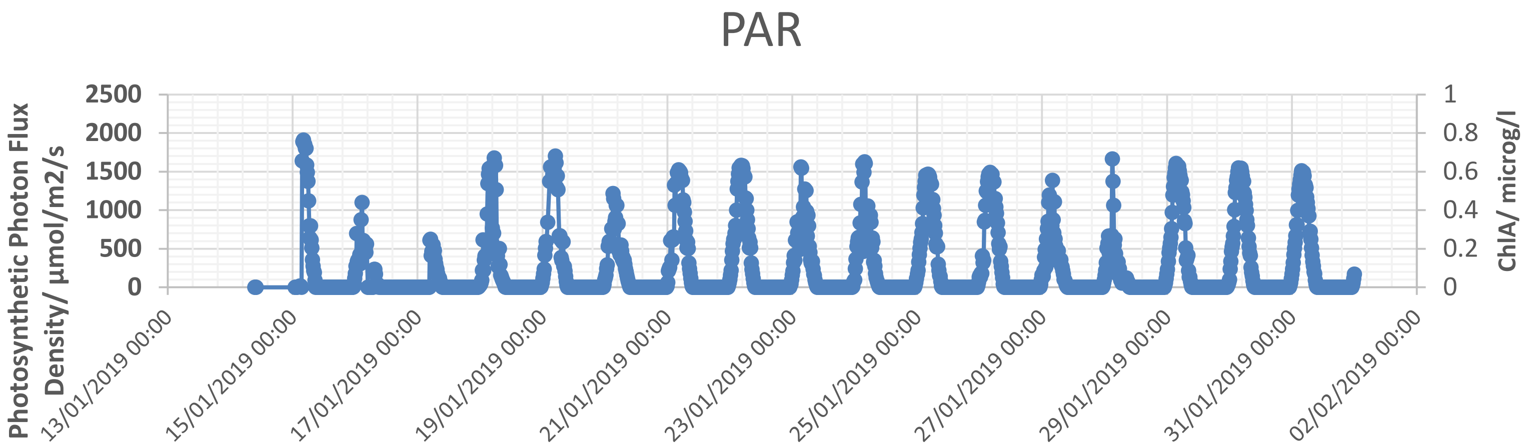
Conclusion: Sensors do not entirely replace manual monitoring measurements

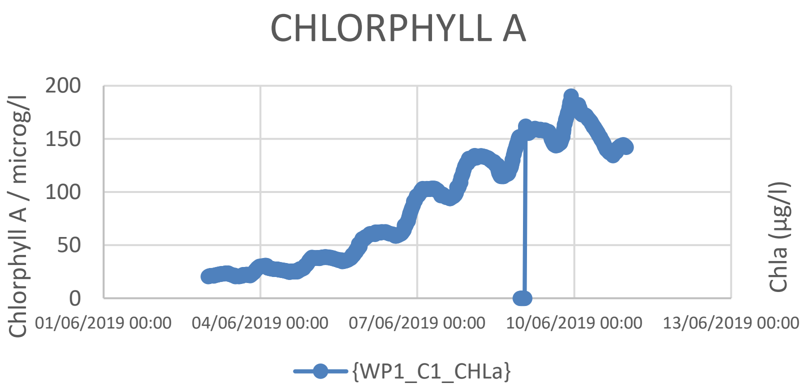
Monitoring of algae system - automation

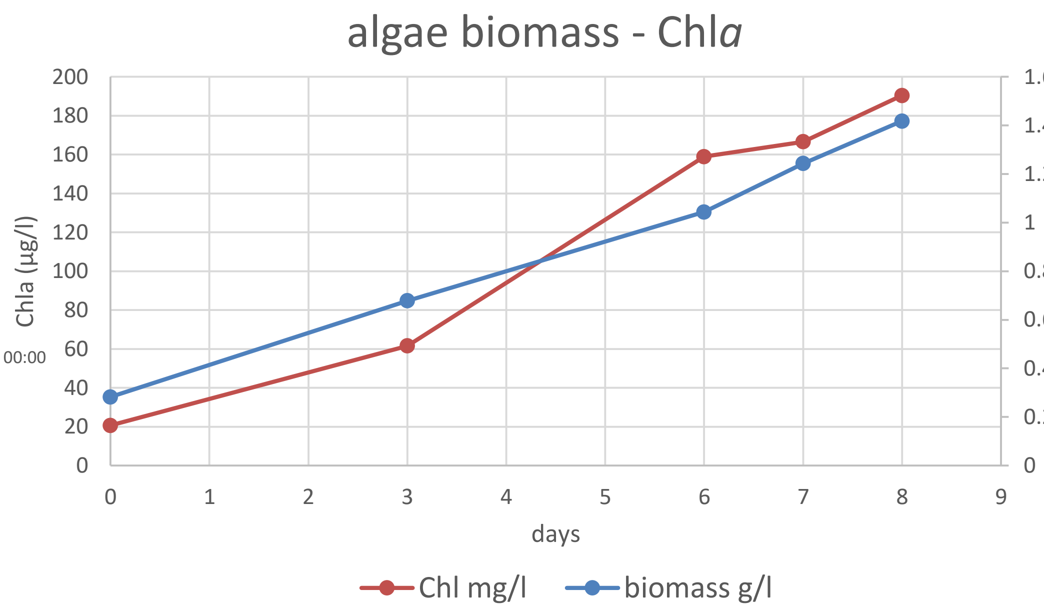




Monitoring of algae system - automation





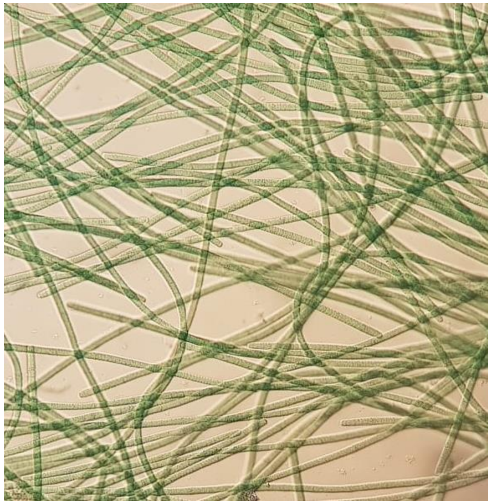


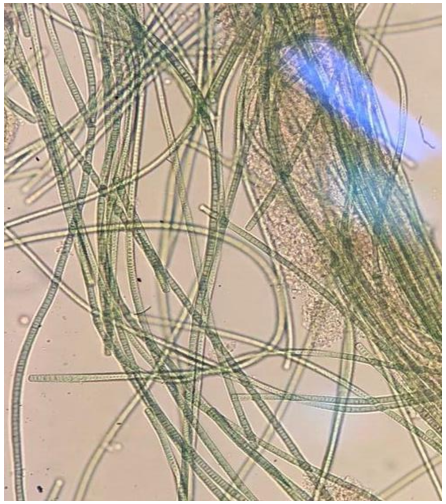
Monitoring of algae system - lab

	pH	Salinity dS/m	NO_3 mg/l	PO_4 mg/l	BOD mg/l	COD mg/l	TOC mg/l	TSS mg/l
Waste water	7.4	2.4	**150-200**	**10-20**	**20-50**	**80-100**	**15-20**	**15-30**
Pre-treated water (DAF)	7.2				**5-15**	**20-40**	**<10**	**5**
Harvest water	9.0	**6-8**	**10-20**	**0-10**				
RO desalinated water	9.0	**0.3**	8	0	3	25	6	5
RO Brine	8.5	11	30	20	50	110	25	30
Reduction		**95 %**	**90 -95%**	**100 %**	**60-90 %**	**60-80%**	**50-70%**	**80%**

Monitoring of algae system - lab

Microscopy observation of cultures

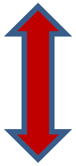


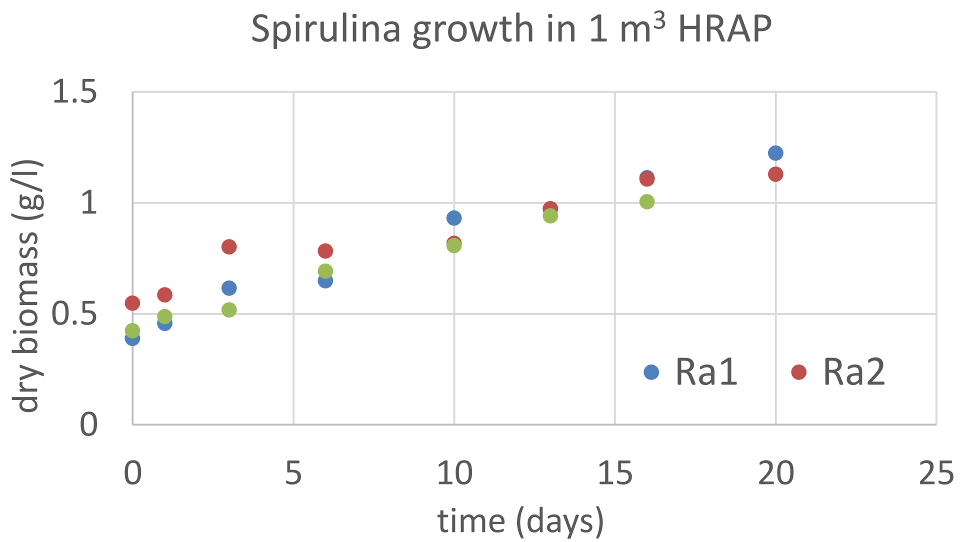


- Some contamination of other microalgae species and microorganisms is visible
- Naturally, bacteria, possible other cyanobacteria occur, difficult to identify with microscopy
- PTP - genetic identification of bacterial and microalgae species within Spirulina cultures in HRAPs and in wastewater

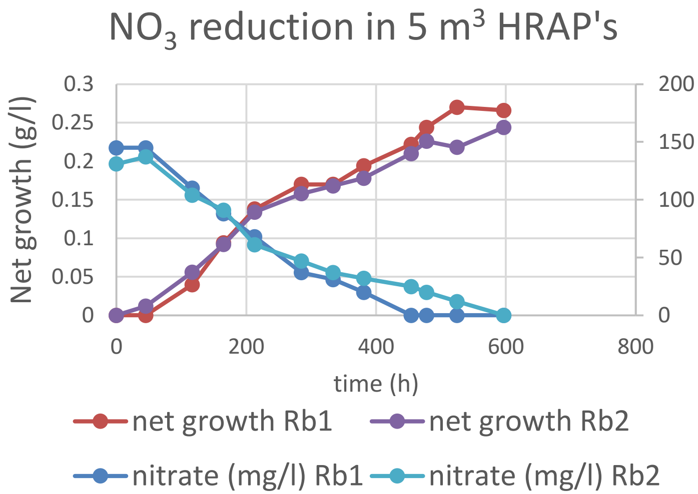
Monitoring of algae system - lab

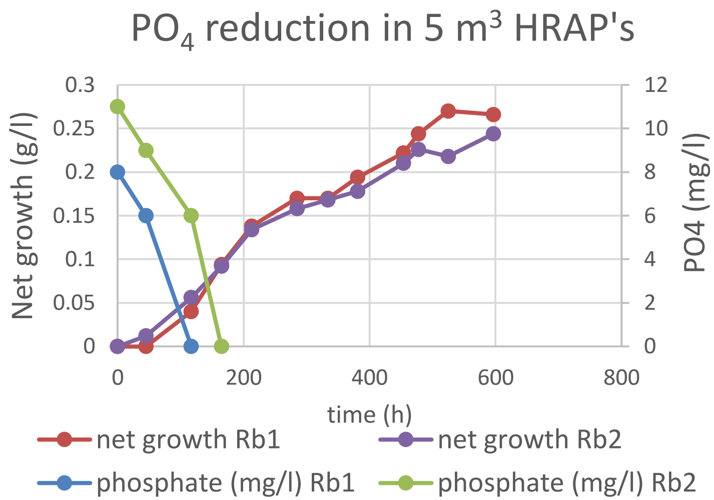
Biomass growth in HRAP



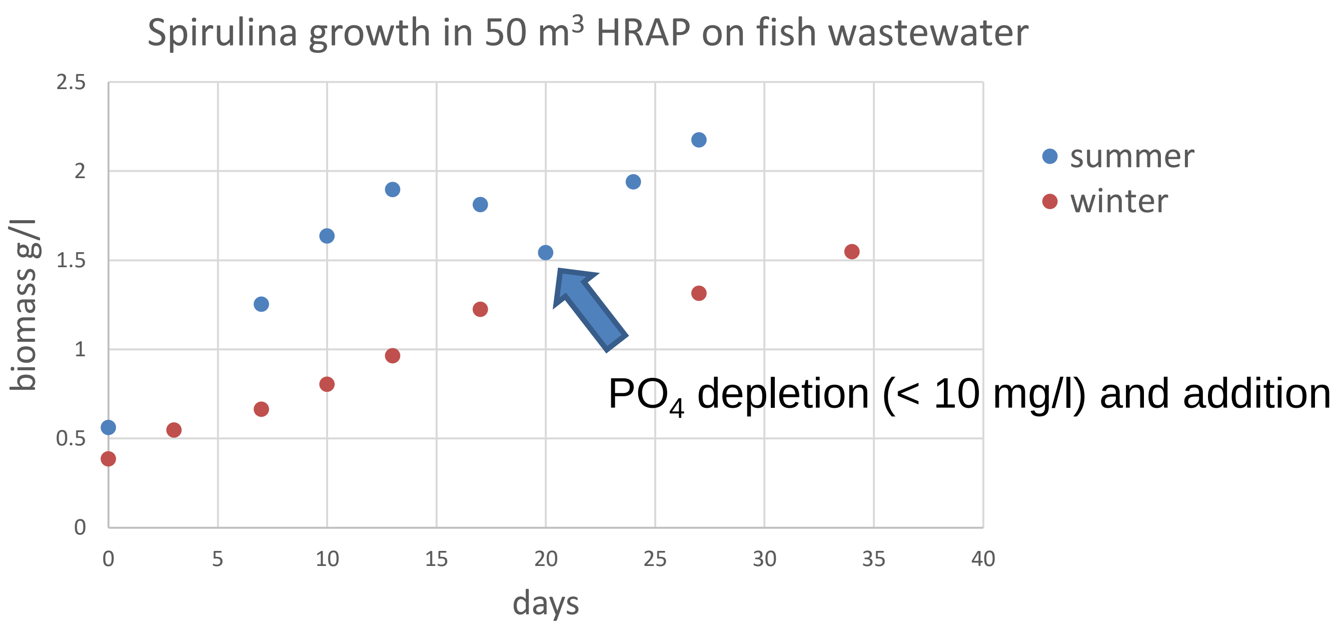


Reduction of NO_3 and PO_4





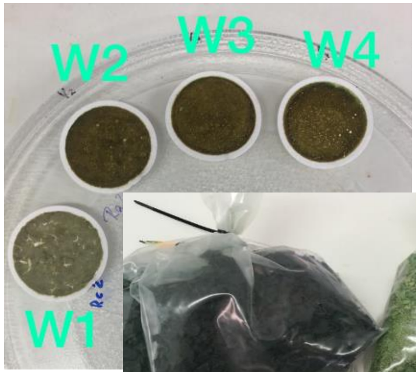
Algae biomass



- Maximum biomass >1 g/l all year around
- Growth rate reduced in winter vs. summer (10-12 vs. 5-6 days)
- Long time culture in continues growth mode of up to 3-4 month
- Evaporation about 4%, compensated with regular water/wastewater

Harvest

- Vibration sieve reduces 90-95% water
- 5-10% volume of harvest water used for washing algae biomass and reduces salt content in biomass



- Solar oven drying – economical solution, no decrease in dried biomass quality

Extractis analysis			
dried biomass	dry Matter (%)	minerals (%/DM)	proteins (%/DM)
50 °C oven 24 h	91.6	30.2	52.7
solar oven 24 -72 h	85.1	29.8	54.6

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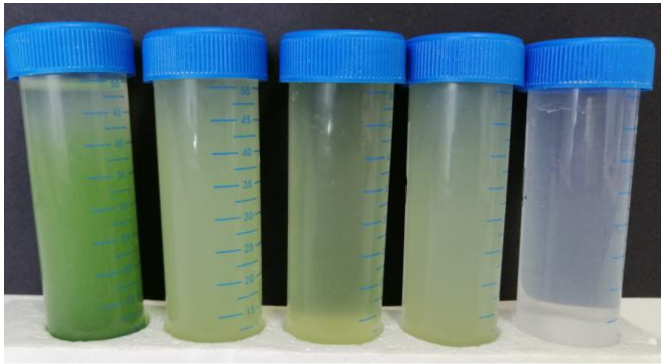
Harvest - Water recovery RO

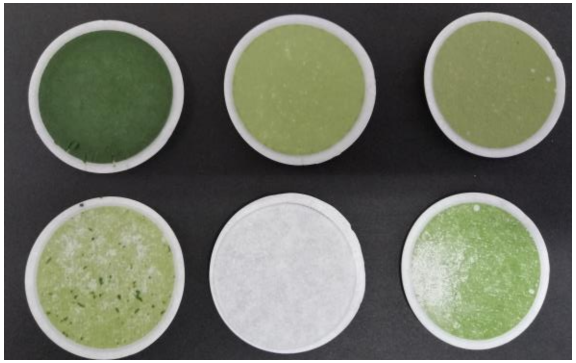
- Harvest water contains shorter Spirulina filaments (up to 40%)
  - vibration sieve vs. UF/centrifugation
- Pre-filtration prior RO necessary (20 µm)

AC – HW



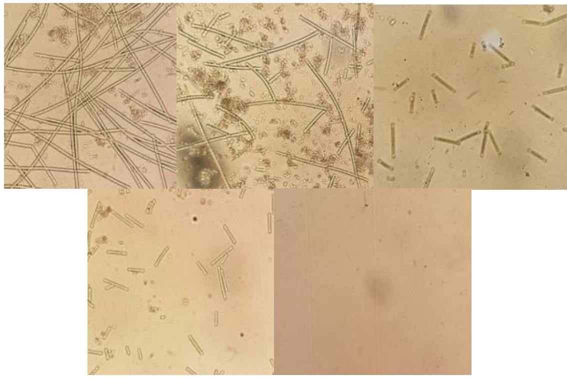
B – DW

AC – HW



B – DW

AC – HW



B – DW

- Flow set to 2 m^3/h, 50:50 desalinated water:brine
- Outflow water EC 0.3 dS/m, high pH (9.0)
- Brine contains Spirulina fragments (< 10%)

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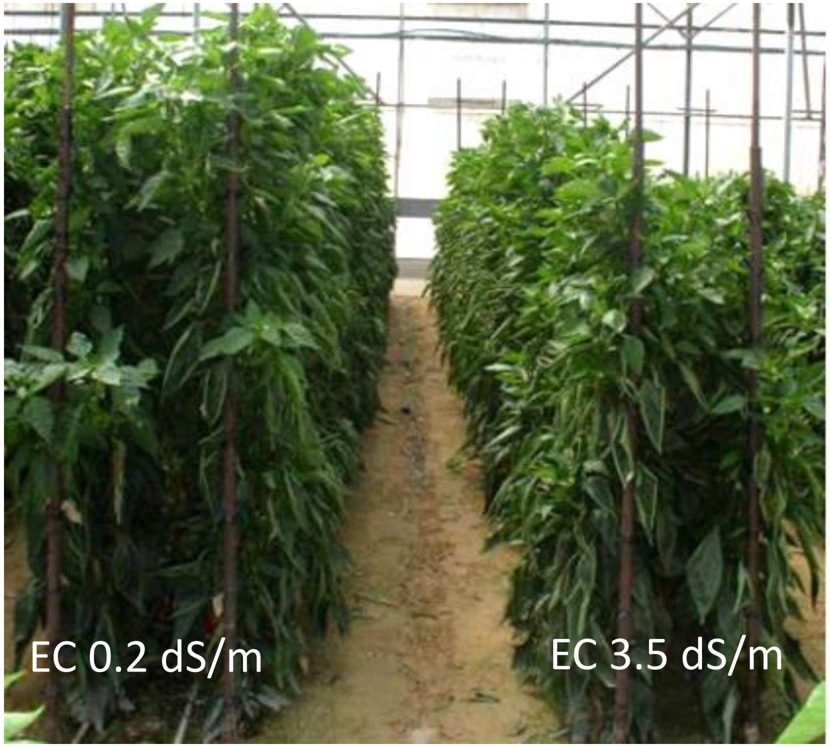
RO outflow applications

Desalinated water

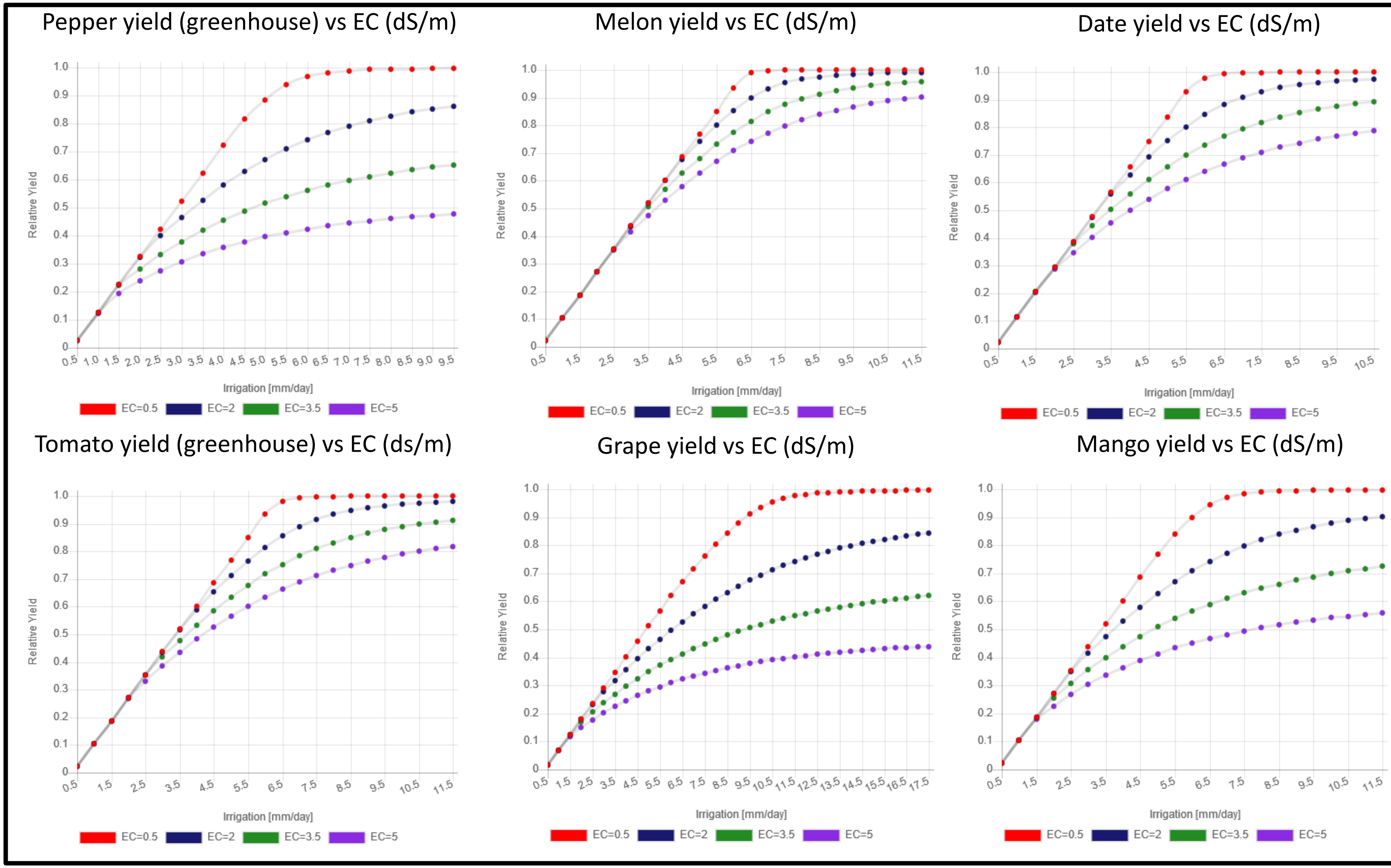
- Agricultural area
- irrigation water up to EC of 4.5 dS/m
- Reduced crop growth and yield

- Using desalinated water would
- ✓ Increase crop yield
- ✓ Allow higher crop diversity
- ✓ Reduce in water consumption

- high pH causes changes in soil chemistry and would require to adapt fertigation (for iron and phosphate)



Desalinated water applications



Relative yield of 6 different crops grown in the Arava under different quantities and qualities (EC) of irrigation water. (Shani et al., 2007, source: https://app.agri.gov.il/AnswerApp)

RO outflow applications

Brine

- recirculation into algae ponds

✓ Reduces salt input, saves water
✓ compensate for evaporation

- Solar drying – salt production (low value)

Conclusion:

- desalinated water outflow from RO unit is of high value for crop irrigation
- Brine recirculation reduces salt input and water consumption

ARAVA demo site achievements

Objectives	Status
System establishment (PBR, HRAP, DAF, Harvest, RO)	+
Continuous rearing of the selected fish and algae species in the system	+
Demonstration of excess nutrient removal (water analyses)	+
Removal of sludge	+
Efficient production and harvesting of algal biomass >10 g/m^2/day of algal biomass 5 kg/m^3/month of fish	+
Demonstration of statistically significant increase of crop yield due to use of desalted water	+

inspiralia

Bibo Aqua

Archimede Ricerche Srl

algen algal technology centre

KOTO

Arava Development Co.

DCU

PTP SCIENCE PARK

OXIDINE Water Technology

NOVA id FCT Associação para a Inovação e Desenvolvimento da FCT

PRODUMIX

EXTRACTIS

INSTM

iBET Instituto de Biologia Experimental e Tecnológica

EUBIA

enco engineering & consulting

FOOD+i CLUSTER

European Desalination Society

SP your Science Partner

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