Use of Algae EWS to Maximize Profits in Algae Endeavors

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OriginOil EWS Technologies

Electro Water Separation (EWS) is a water treatment system that applies electromagnetic pulses to a water media in order to perform functions such as Ammonia removal, Kill bacteria, rotifers and other microorganisms, harvest microalgae and remove chemicals. There are two EWS products offered to Aquaculture producers: A60 Algae Harvester, and Q60 Ammonia removal units.

Q60 Ammonia & Bacteria removal unit

A60 Algae Harvesting unit

What can OriginOil do for Algaepreneurs?

Capital Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms)

Capital Cost Items	Costs in US dollars
Site prep., grading, compaction	5000
Pond levees, hydraulic structures	3500
Mixing device (paddle wheels)	12000
Anti-infiltration Lining	20000
CO2 injection device	15500
Water and nutrient supply equip	5200
Buildings, roads, drainage	2500
Electrical wiring and distribution	2500
Subtotals of above	66200
Engin.& Contingencies(15% above)	9930
Total direct capital	76130
Land Costs	5000
Total Capital Investment	**81130**

$81130 financed for 10 years at 5% yr interest yields an annual payment of **$10326 dollars/yr**

Fixed Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms)

Fixed Operational costs

Operational Cost Items	Costs in US dollars/yr
Labor (2 full time operators)	100000
Elect (5.16 KW , $0.1 dollars/Kwh)	4458
Maintenance (5% of Initial Capital)	4056
Management/Administration	10000
Cost of Sales	10000
Total Fixed Op Costs/yr	**128514**

Ops Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms) 20 g/m2-Day or 72000 Kg Algae/year

Variable Ops costs

Operational Cost Items	Costs in US dollars/yr
CO2 ($27.65 Dollars/Ton) 2.0 Kg CO2/Kg Algae	3982
N- Urea (418 Dollars/Ton) 0.2 08 Kg Urea/Kg Algae	6260
P-DAP ($565 Dollars/Ton) 0.02 Kg DAP/Kg Algae	814
K- KCl (456 Dollars/Ton) 0.0057 Kg KCl/Kg Algae	187
Fe- FeSO4 (100 Dollars/Ton) 0.025 Kg /Kg Algae	180
Micronutrients (300 Dollars/Ton) 0.01 Kg/Kg Algae	216
Total Variable Op Costs/yr	**11639**

What can OriginOil do for Algaepreneurs?

Capital Cost Estimates of 1 Ha-microalgae producing PBR (Close loop PBR Paradigms)

Capital Cost Items	Costs in US dollars
Site prep., grading, compaction	5000
Pond levees, hydraulic structures	3500
Hydraulic Hardware Control	50000
Programmable Control System	12500
Transparent bags/plumbing	75000
Anti-infiltration Lining	20000
CO2 injection device	15500
Water and nutrient supply equip	10400
Buildings, roads, drainage	2500
Electrical wiring and distribution	2500
Subtotals of above	196900
Engin.& Contingencies(15% above)	29535
Total direct capital	226435
Land Costs	5000
Total Capital Investment	**231435**

$ 231435 financed for 10 years at 5% yr interest yields an annual payment of **$29457 dollars/yr**

Fixed Cost Estimates of 1 Ha-microalgae producing PBR (Conventional Close Loop Paradigms)

Fixed Operational costs

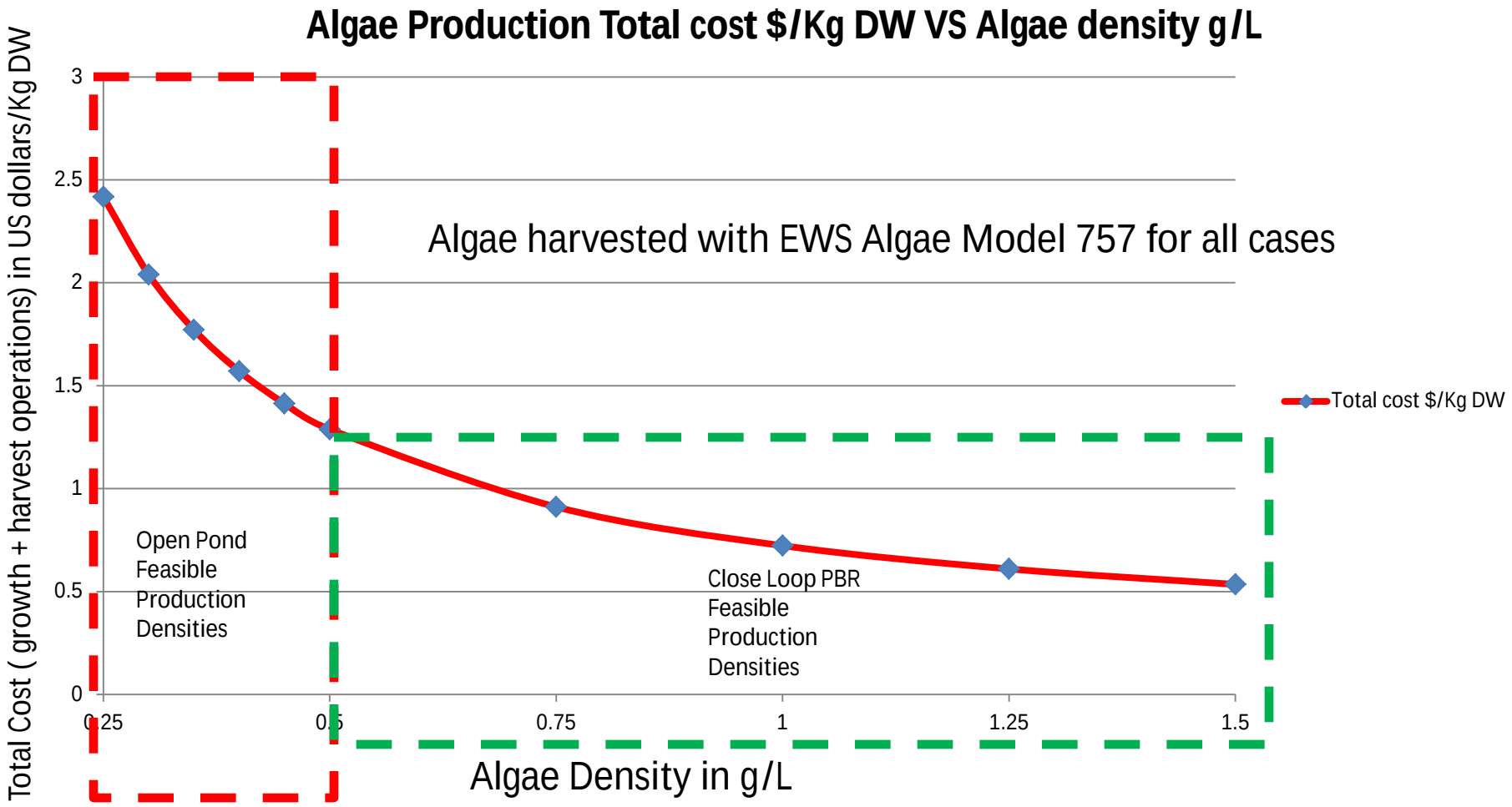
Operational Cost Items	Costs in US dollars/yr
Labor (1 full time operator)	50000
Elect (12.84 KW , $0.1 dollar/Kwh)	11094
Maintenance (3% of Initial Capital)	6493
Maintenance of Bags	20000
Management/Administration	10000
Cost of Sales	10000
Total Fixed Op Costs/yr	**107587**

Ops Cost Estimates of 1 Ha-microalgae producing PBR (Conventional Paradigms) 50 g/m2-Day or 180000 Kg Algae/year

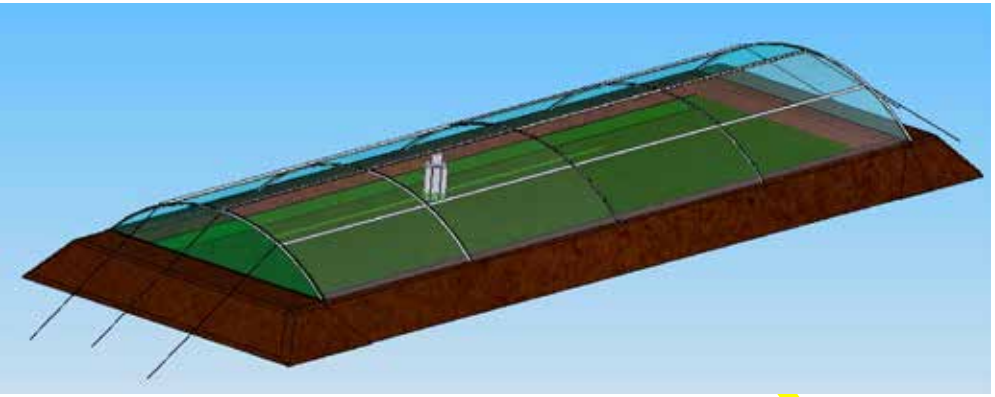
Variable Ops costs

Operational Cost Items	Costs in US dollars/yr
CO2 ($27.65 Dollars/Ton) 2.0 Kg CO2/Kg Algae	9954
N- Urea (418 Dollars/Ton) 0.2 08 Kg Urea/Kg Algae	15650
P-DAP ($565 Dollars/Ton) 0.02 Kg DAP/Kg Algae	2034
K- KCl (456 Dollars/Ton) 0.0057 Kg KCl/Kg Algae	468
Fe- FeSO4 (100 Dollars/Ton) 0.025 Kg /Kg Algae	450
Micronutrients (300 Dollars/Ton) 0.01 Kg/Kg Algae	540
Total Variable Op Costs/yr	**29096**

The larger Production Density, the least cost per Kg DW

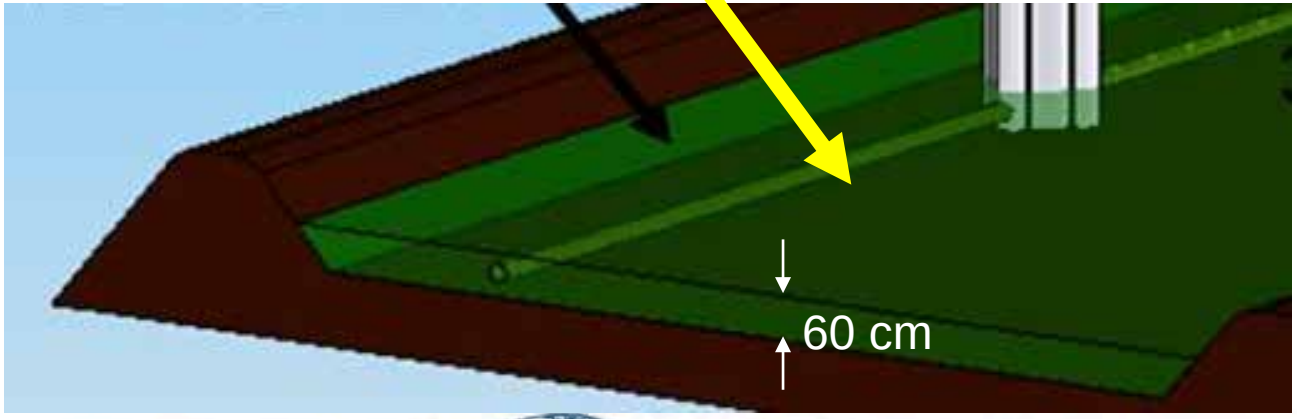


Why Harvesting is so Important for Profitability?



Example:

We have a roofed pond containing Nannochloropsis culture with a water column depth of around 60 centimeters. The algae culture collapsed, given that such water column depth prevents light to properly irrigate the algae cells through the column, inducing the death and decay of part of the algae biomass. The presence of dead algae biomass induces the decay of the rest of the culture due to the fact that it acts as a focus of infection where bacteria and fungus thrive and produces toxic compounds such as hydrogen sulfide.



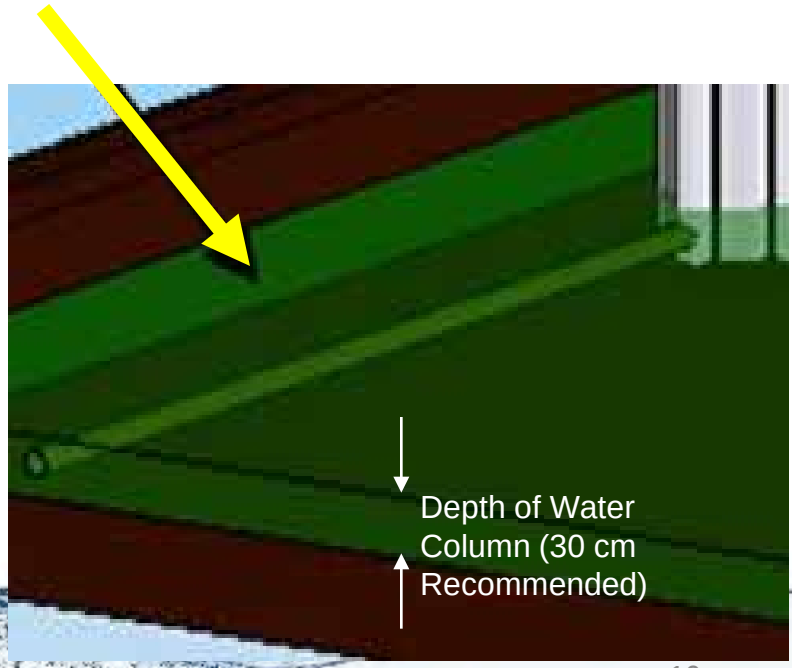
Why Harvesting is so Important for Profitability?

The following graph displays the percentage of incident light penetrating the algae water column for different concentrations of algae biomass.

It is clear that the larger the concentration of algal biomass, the less the percentage of incident light that reaches the algae cells located deeper inside the water column. The desired algae concentration for optimal algae growth production in commercial operations ranges from 350 mg/L to 500 mg/L. For these algae concentration levels, light does not penetrate beyond 30 cm deep. This is the reason for which **it is recommended to keep the algae culture water column at or below 30 centimeters.**

Percentage of incident light penetrating with the change in biomass concentration

Depth (mm)	25.4	50.8	76.2	101.6	127.0	152.4
Biomass Concentration (g/L)						
0.1	95.46%	91.19%	87.17%	83.39%	79.84%	76.49%
0.2	91.19%	83.39%	76.49%	70.36%	64.90%	60.04%
0.3	87.17%	76.49%	67.55%	60.04%	53.69%	48.31%
0.4	83.39%	70.36%	60.04%	51.80%	45.16%	39.77%
0.5	79.84%	64.90%	53.69%	45.16%	38.58%	33.43%
0.6	76.49%	60.04%	48.31%	39.77%	33.43%	28.62%
0.7	73.33%	55.69%	43.71%	35.34%	29.34%	24.91%
0.8	70.36%	51.80%	39.77%	31.68%	26.05%	21.98%
0.9	67.55%	48.31%	36.37%	28.62%	23.36%	19.63%
1	64.90%	45.16%	33.43%	26.05%	21.14%	17.72%
2	45.16%	26.05%	17.72%	13.33%	10.67%	8.89%
3	33.43%	17.72%	11.85%	8.89%	7.11%	5.93%
4	26.05%	13.33%	8.89%	6.67%	5.33%	4.45%
5	21.14%	10.67%	7.11%	5.33%	4.27%	3.56%
6	17.72%	8.89%	5.93%	4.45%	3.56%	2.96%
7	15.22%	7.62%	5.08%	3.81%	3.05%	2.54%
8	13.33%	6.67%	4.45%	3.33%	2.67%	2.22%
9	11.85%	5.93%	3.95%	2.96%	2.37%	1.98%
10	10.67%	5.33%	3.56%	2.67%	2.13%	1.78%



Why Harvesting is so Important for Profitability?

Percentage of incident light penetrating with the change in biomass concentration

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0.9	67.55%	48.31%	36.37%	28.62%	23.36%	19.63%
1	64.90%	45.16%	33.43%	26.05%	21.14%	17.72%
2	45.16%	26.05%	17.72%	13.33%	10.67%	8.89%
3	33.43%	17.72%	11.85%	8.89%	7.11%	5.93%
4	26.05%	13.33%	8.89%	6.67%	5.33%	4.45%
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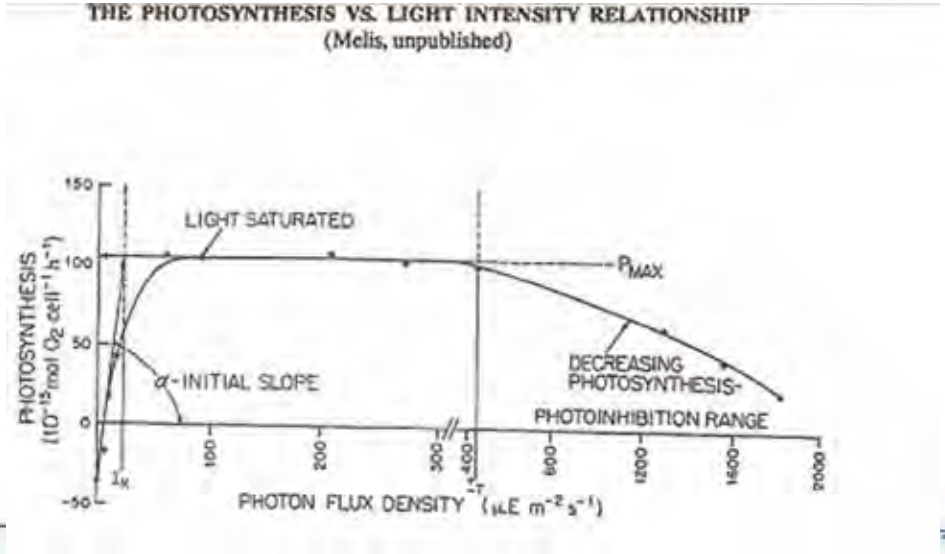
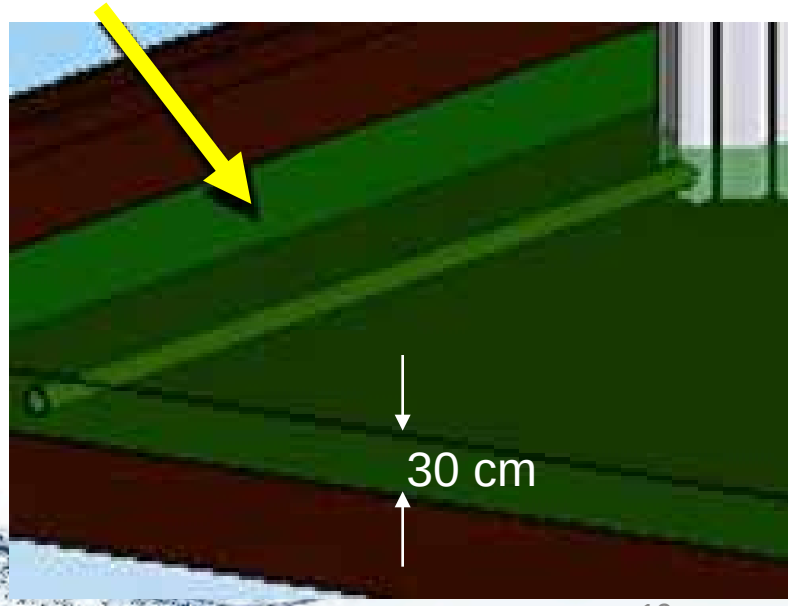
6	17.72%	8.89%	5.93%	4.45%	3.56%	2.96%
7	15.22%	7.62%	5.08%	3.81%	3.05%	2.54%
8	13.33%	6.67%	4.45%	3.33%	2.67%	2.22%
9	11.85%	5.93%	3.95%	2.96%	2.37%	1.98%
10	10.67%	5.33%	3.56%	2.67%	2.13%	1.78%

Why Harvesting is so Important for Profitability?

The reason for which the desired algae concentration for optimal algae growth production in commercial operations ranges from 350 mg/L to 500 mg/L stems from the fact that these densities have enough algae cells to prevent the Light Saturation Effect. Light Saturation effect is a sudden decrease in photosynthesis that algae cells present if subjected to light irradiation levels above a threshold (usually above 500 microEinsteins/m2-sec or ¼ of the full light in a cloudless mid-day in August). The value of this light saturation threshold varies from species to species as well as due to the temperature of the water where the algae grows (the colder the water, the lower the threshold). If a large algae commercial production system is inoculated with less than 100 mg/L, usually crashes or is unable to sustain production due to Light Saturation Effect.





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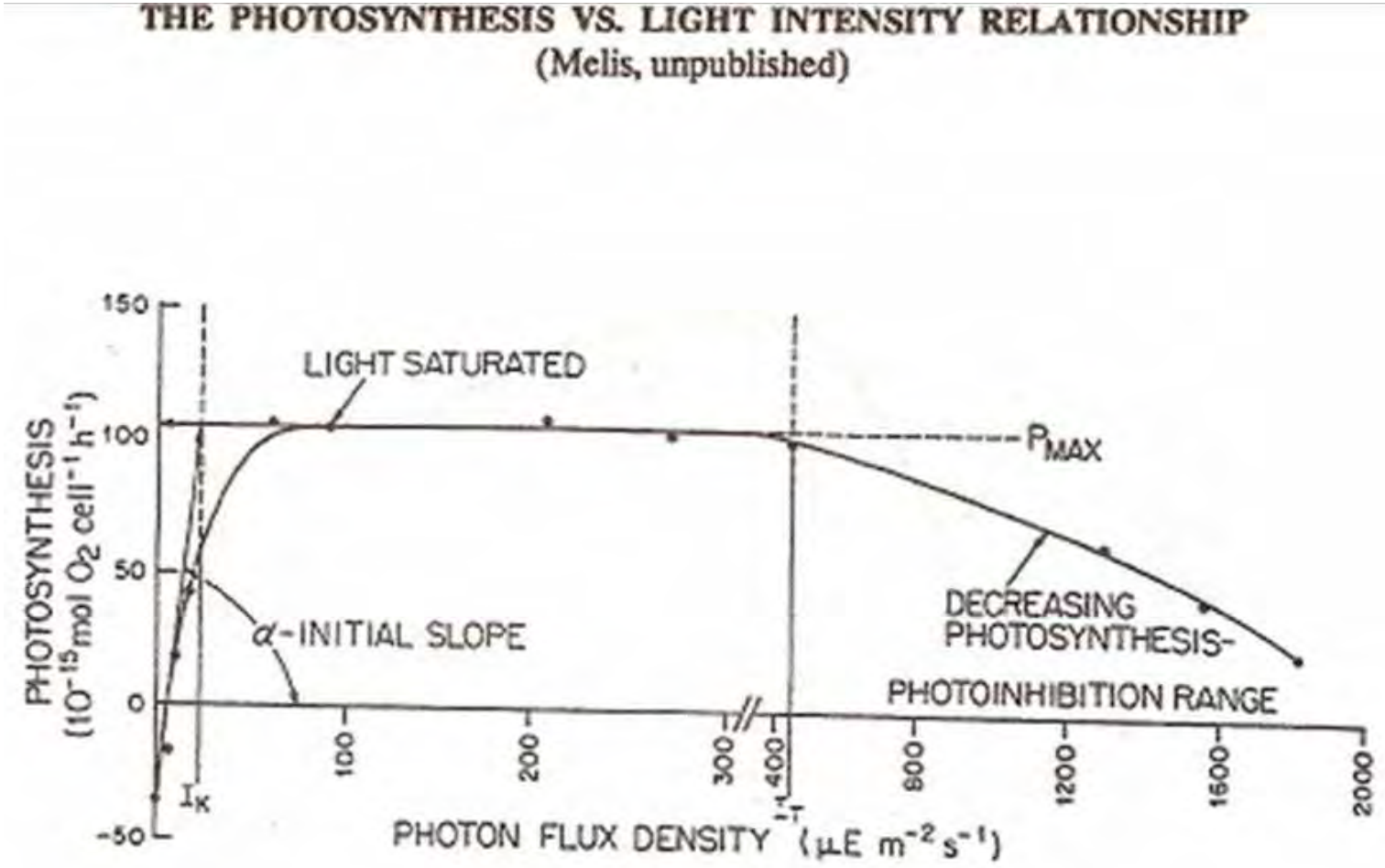


Why Harvesting is so Important for Profitability?

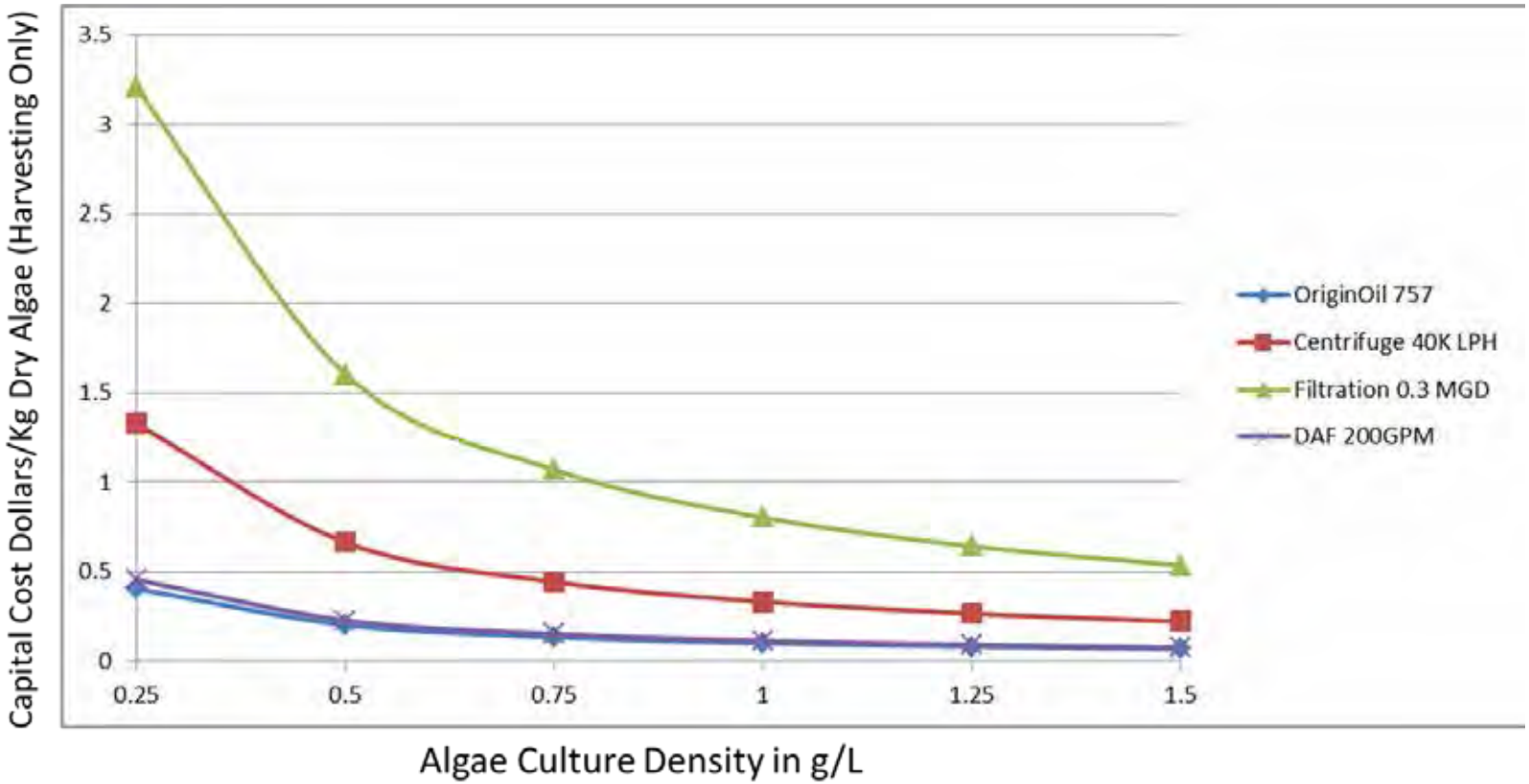
Culture Dilution

Culture dilution consists in removing part of the microalgal culture medium from the growth system and replacing this portion with fresh medium. **The main objective of culture dilution is to keep the translucency in the algae culture within a desired range in order to keep a balance that allows enough light to irrigate most of the algal cells within the water column while having enough algae cells to prevent the light saturation effect by self-shadowing the incident light below inhibition levels for most of the cells.**

Other benefit of diluting an algae culture is that it could aid to replenish nutrients in enough quantity to assure the optimum growth of the microalgae between two consecutive dilutions.

Big Deal… I can harvest with whatever I want… (really?)

Total Cost of Harvesting in US dollars per Kilogram of dry Algae for different culture densities
Costs in the USA (Including Labor and consumables)



The OriginOil EWS Algae Harvesting Solution

- OriginOil's breakthrough algae harvesting system:
  - Lower capital and operating costs than *any* other de-watering process
  - High speed
  - Energy efficient
  - Chemical free
  - Completely scalable
  - Integrates upstream and down
  - Now a standardized, selling product line: **The EWS Algae™**

The EWS Algae

- Fully integrated algae harvester
  - Dewaters more thoroughly
  - Decontaminates to extend shelf life
- Model 12 delivers up to 12 LPM
  - In commercial production and sales
  - Entry-level, low-cost
  - Testing, R&D, process improvement
  - Will process 33% of daily harvest at 60,000-liter/day facility
  - Options: Decontamination, pre-harvest stimulation, capacity upgrade
  - Operator training, literature and support included

The EWS Algae A200

- Commercial algae harvester rated at 200 liters/minute
- Larger harvesters also available

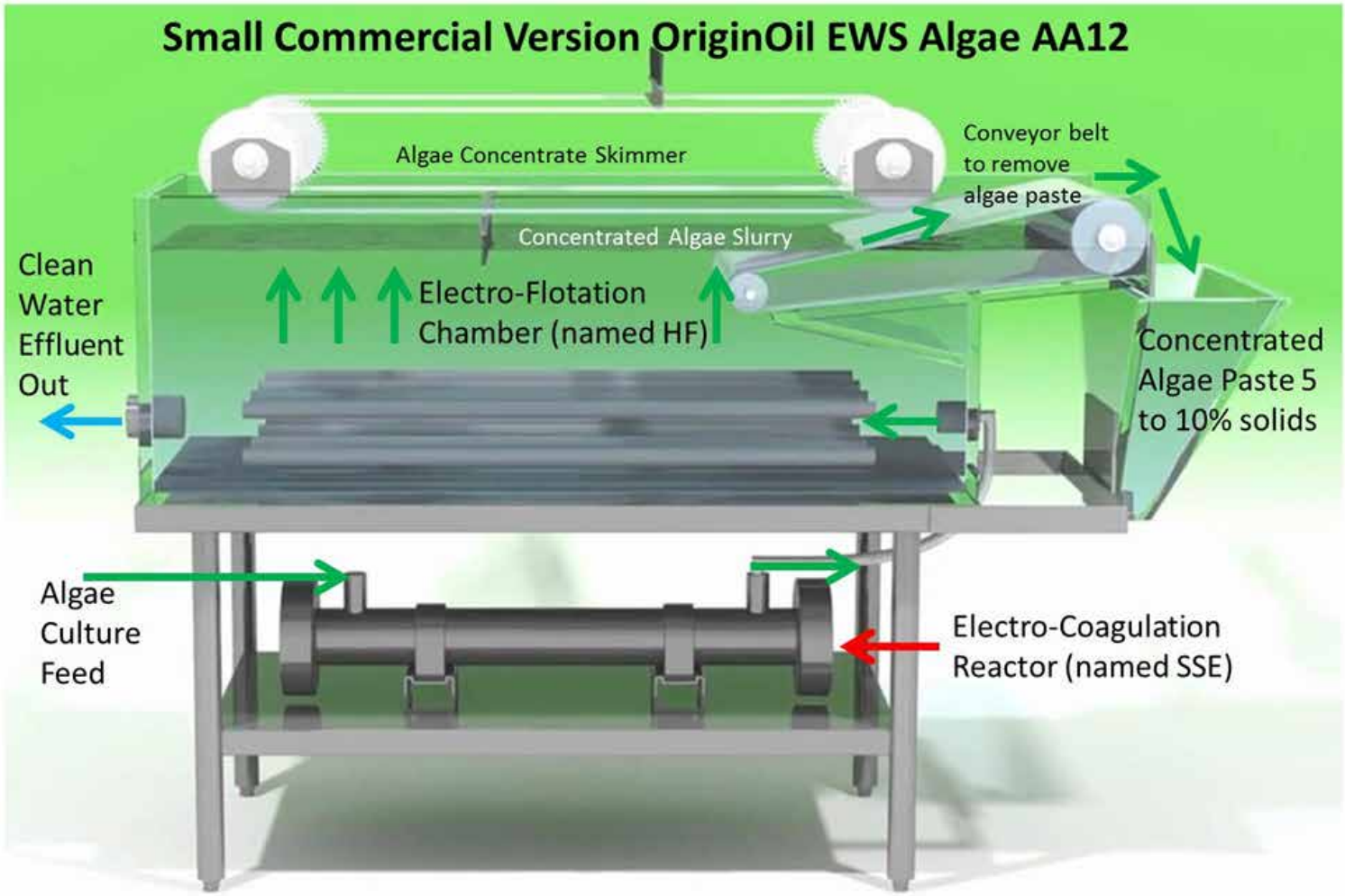
Versatile, Adaptable, Rugged

- Operates with all algae types and conditions: Any strain, salinity, degree of contamination, temperature, grown in autotrophic or heterotrophic mode

Harvesting algae grown in light

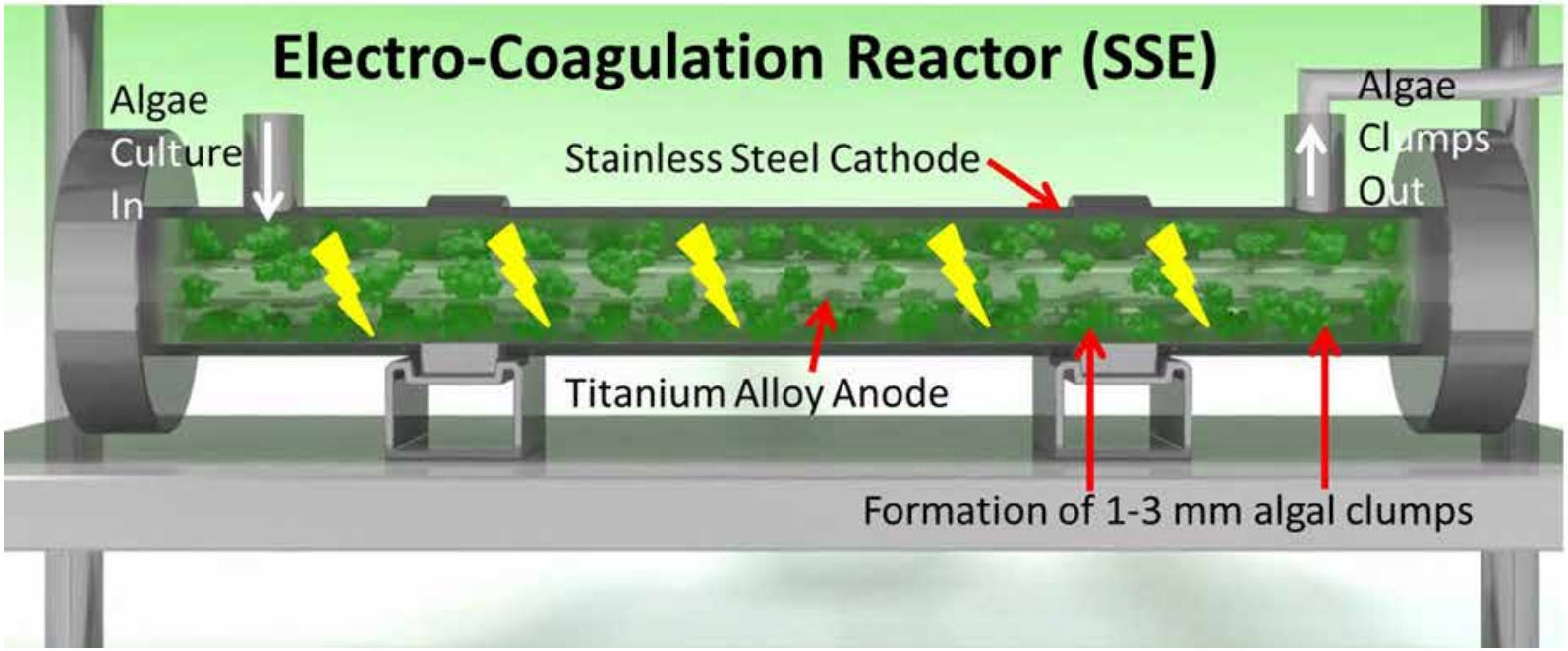
Harvesting algae grown in dark

Two-Stage Harvesting System



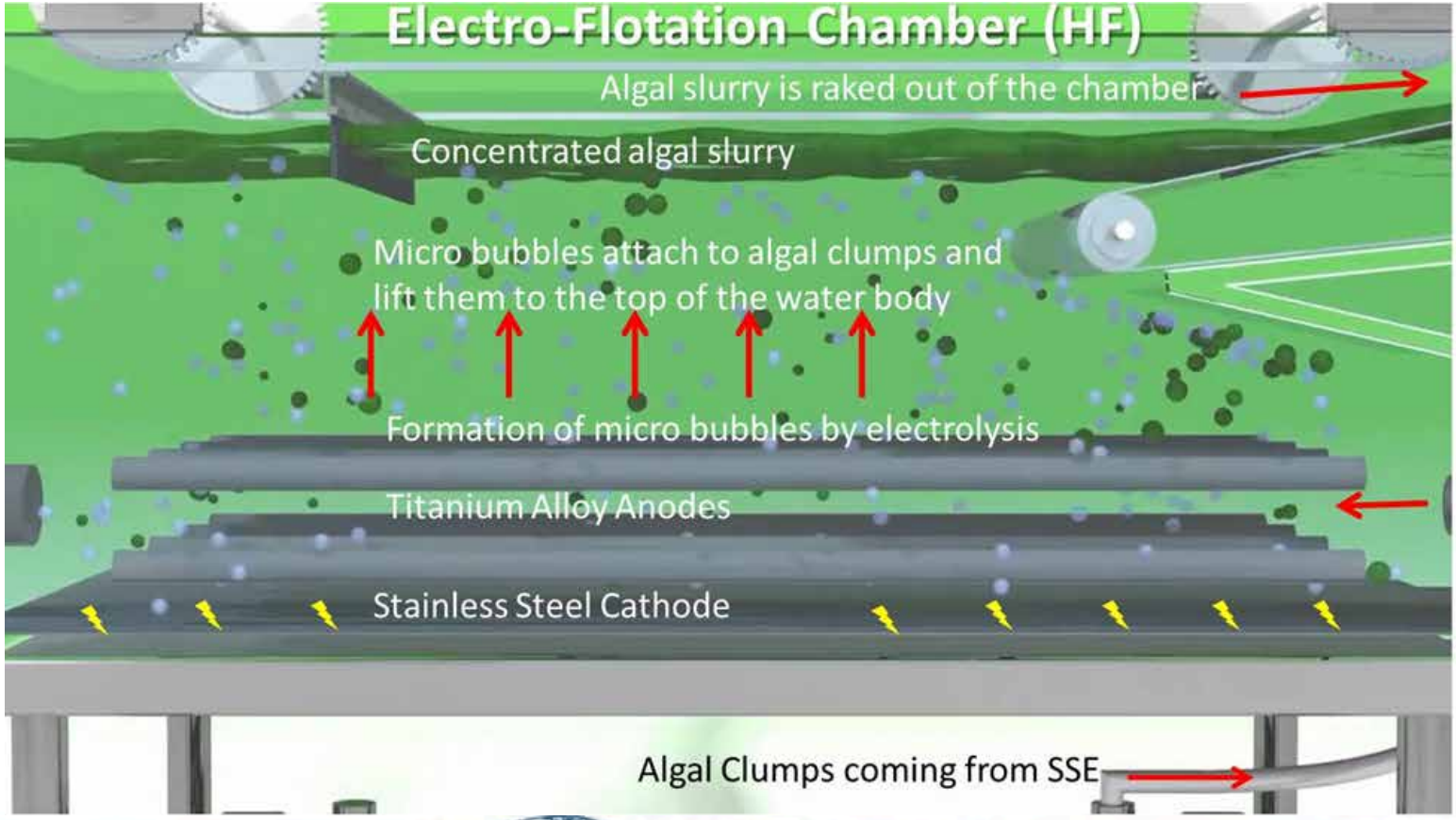
Two-Stage Harvesting System

1. **Single-Step Extraction™ (SSE)** neutralizes algae cells' electrical charge so algae clump together (flocculate). This is a "flocculation" type SSE, which does not damage the algae.

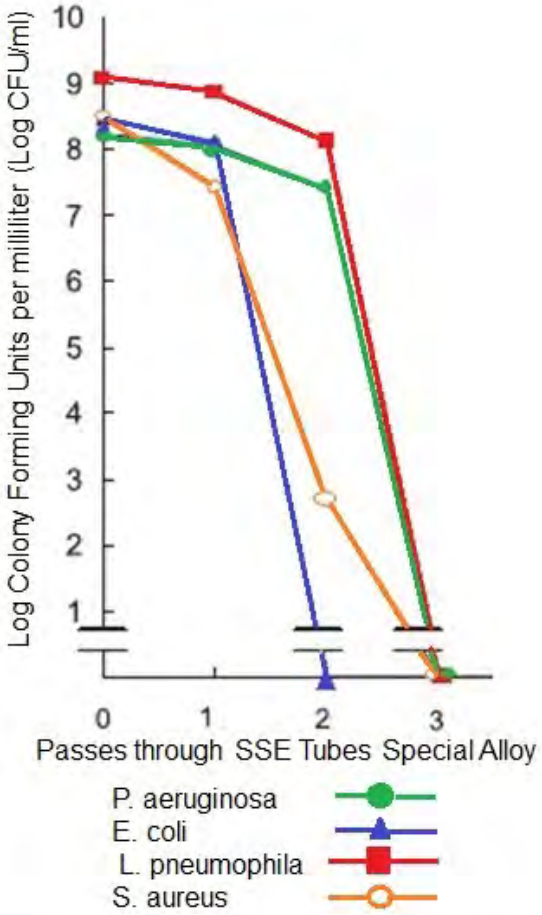


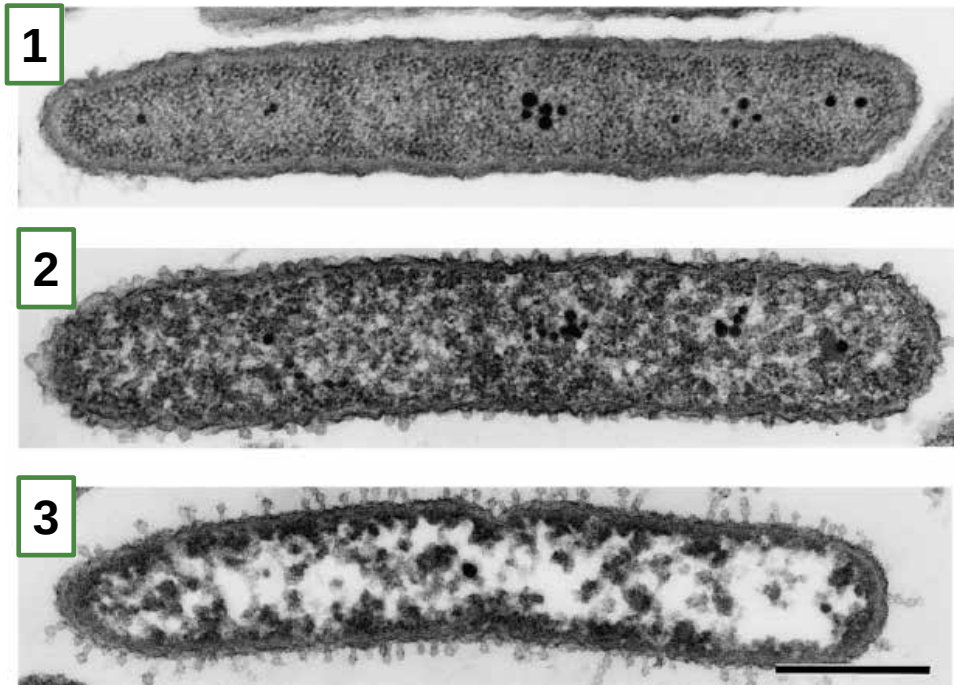
Two-Stage Harvesting System

2. Hydrogen Flotation™ creates a gas cloud of micro-bubbles pushing algae solids upwards for surface collection



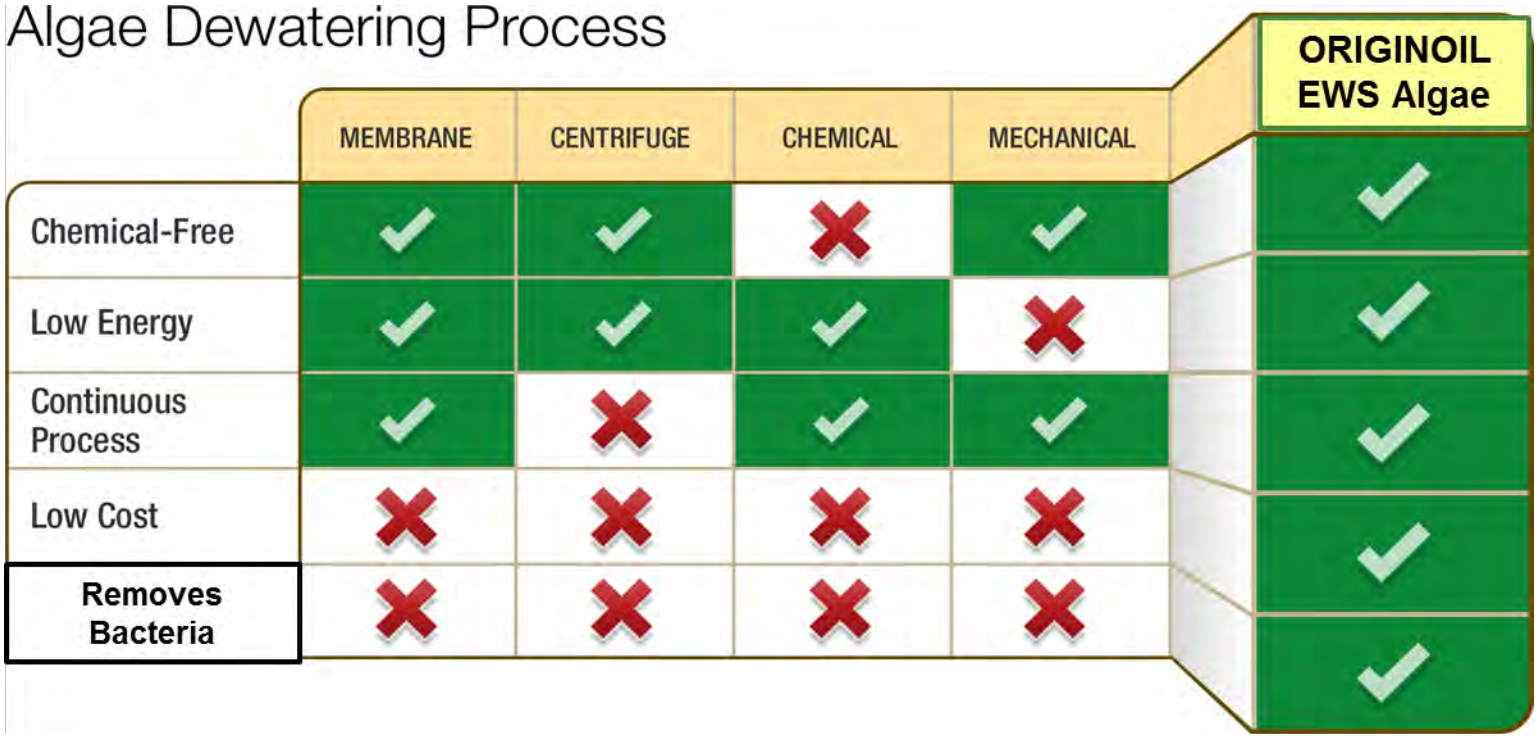
Less bacteria in harvested algae paste and effluent water when harvesting with EWS Algae





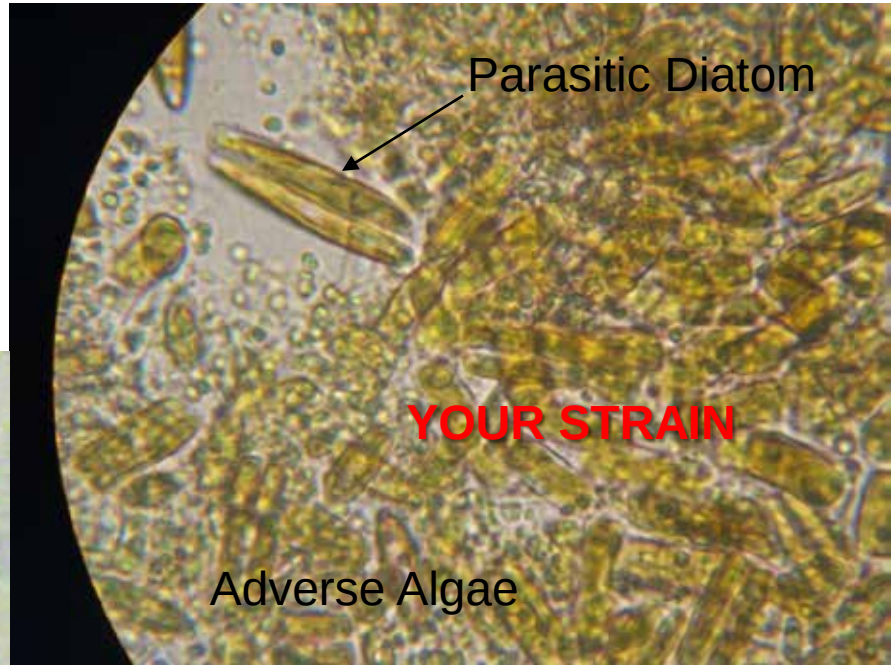
P. aeruginosa after several exposure steps (pay attention at cell walls)

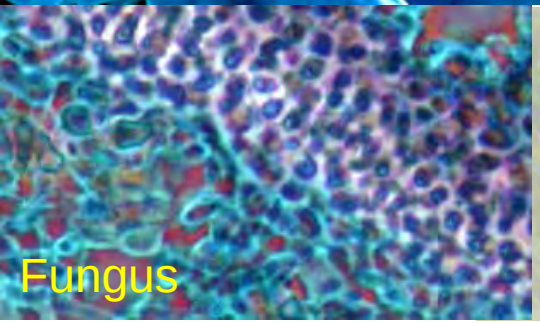
EWS Algae VS other Harvesting Systems

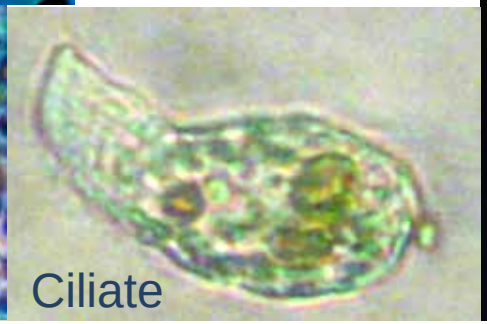


What can OriginOil do for Algaepreneurs?

The Usual Suspects that Crash Algae in Commercial Algae Farming







What can OriginOil do for Algaepreneurs?

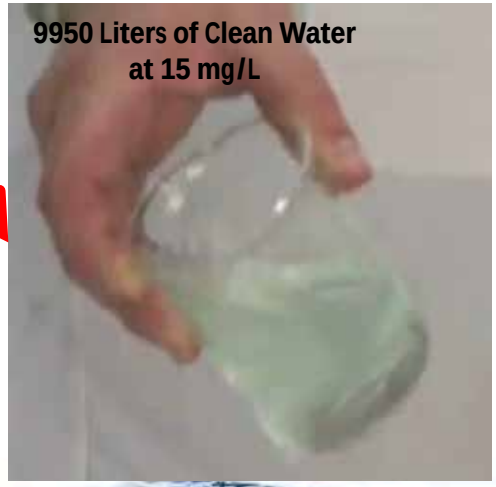
The Drama of Contamination (Conventional Paradigms)

- "It's contaminated, it needs to be discarded"
- Use of Antibiotics
- Use of Chemicals such as Sodium Hypochlorite or Hydrogen Peroxide
- Changes in Salinity, pH or nutrients
- Several days to recover production levels due to Algae Stress/damage

What can OriginOil do for Algaepreneurs?

When farming algae, if Contaminated... Harvest the problems away

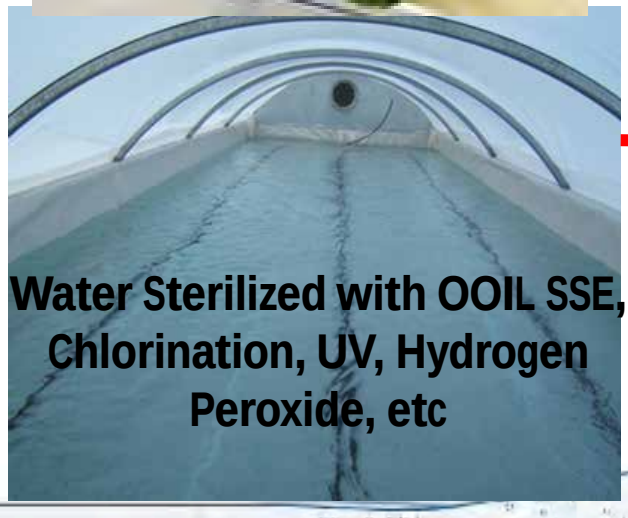
90 to 99% Less Bacteria



What can OriginOil do for Algaepreneurs?

When farming algae, if Contaminated … Harvest the problems away

Algae Paste (The cells are totally alive)



Water Sterilized with OOIL SSE, Chlorination, UV, Hydrogen Peroxide, etc

Back to Production in a few Hour$$$!!!

Algae Farmers Basic Need for Microbiological Control

From a few cells to Inoculation Carboys in the Culture Room

Culture intermediate scale up to 300 gallons in small photobioreactors

Culture production in large photobioreactors up to 15,000 gallon levels

Harvest Biomass without Bacteria

Increased Shelf Life/Quality

What can OriginOil do for Algaepreneurs?

Clean Intake Water and Inoculum Supply

What can OriginOil do for Algae Farmers?

Increase in Production through Heterotrophic Jump

Industrial, Agricultural or Municipal Sewage

OriginOil SSE tubes sterilize and reform sewage yielding a "broth" rich in Organic Carbon and Fertilizers

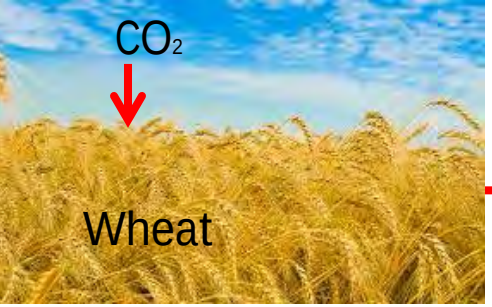
"Broth"

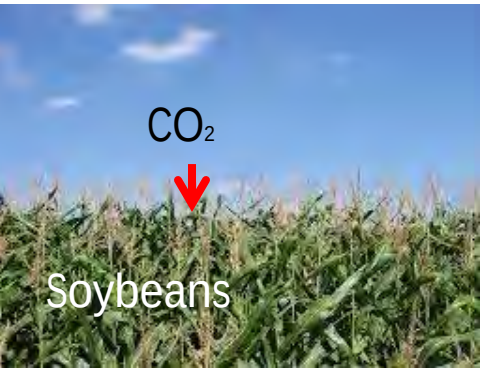
Autotrophic Systems

Alive algae green cells (Harvested with OOIL Appliance)

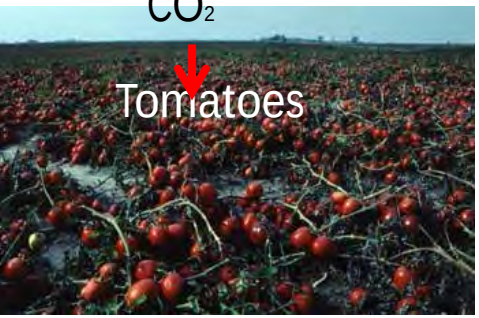
Heterotrophic Systems

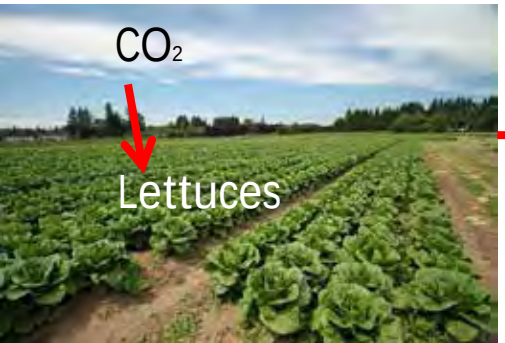
Source of Carbon for Heterotrophic Jump





Organic Carbon

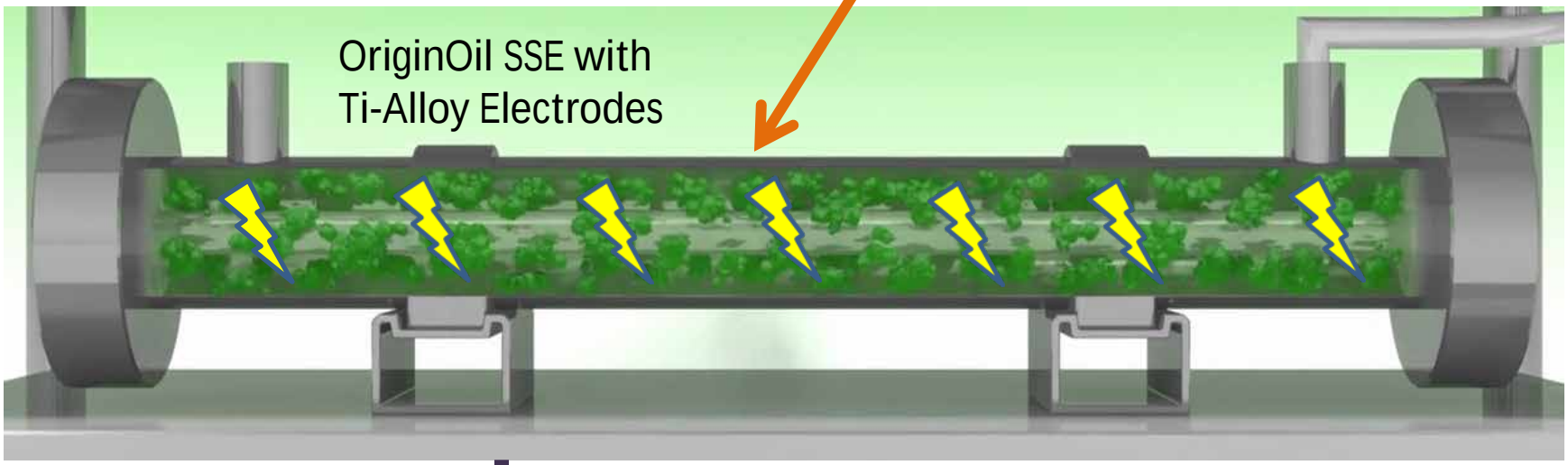




Organic Carbon

Source of Carbon for Heterotrophic Jump

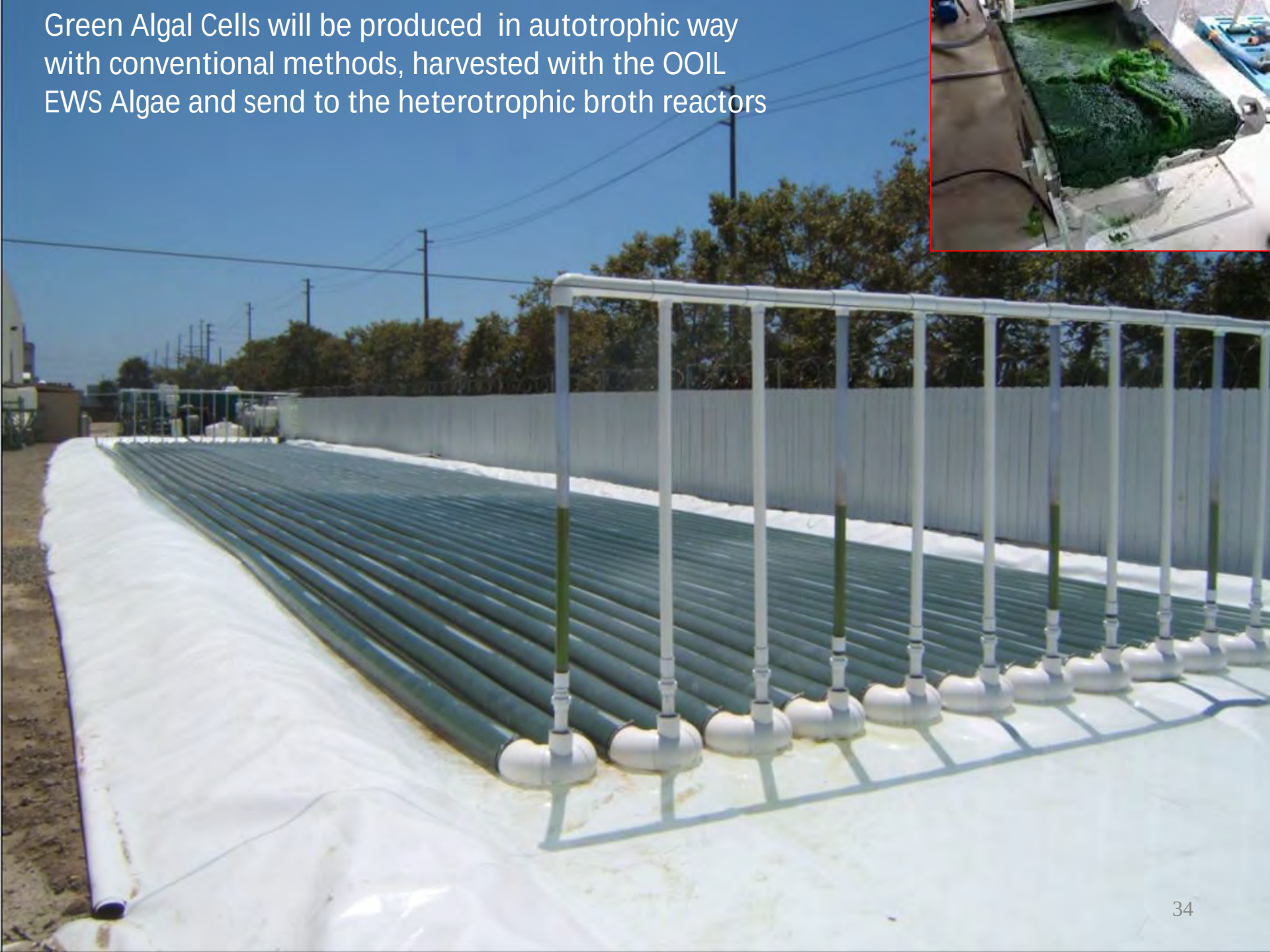
Organic Carbon



Sanitized Organic Carbon with N,P,K, and other nutrients

“Heterotrophic Broth”

Green Algal Cells will be produced in autotrophic way with conventional methods, harvested with the OOIL EWS Algae and send to the heterotrophic broth reactors

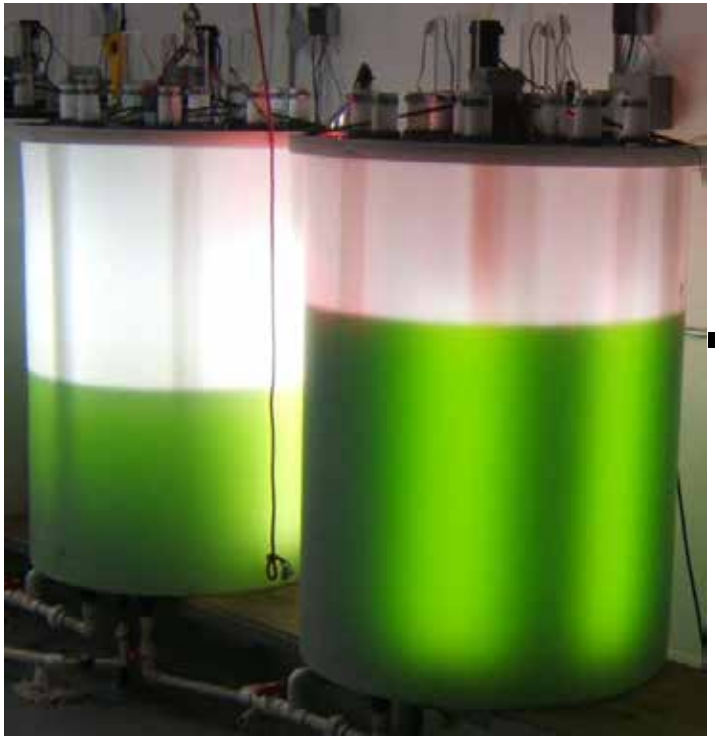



"Heterotrophic Marriage"
Air (Yes, just plain air)
Heterotrophic Broth
Algae Cells from Autotrophic Systems
Shut down the Lights!!!
And Enjoy the Smell of Money!!!

What can OriginOil do for Algaepreneurs?

Increase in Production through Heterotrophic Jump

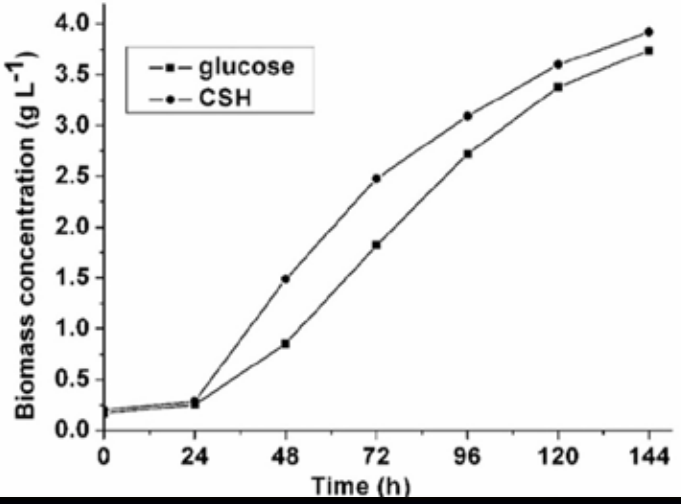
The algae cells produced in autotrophic mode are placed in fermenters that will raise the amount and fat content of algae cells several times. The trick to reduce prices is to assure heterotrophic growth while avoiding contamination without the use of costly beer-industry grade fomenters. This can be achieved by the previous treatment to neutralize micro-organisms of autotrophic algal cells and water by using OriginOil systems



Conventional Autotrophic Algae Systems

Dark (no light) Heterotrophic Algae Systems

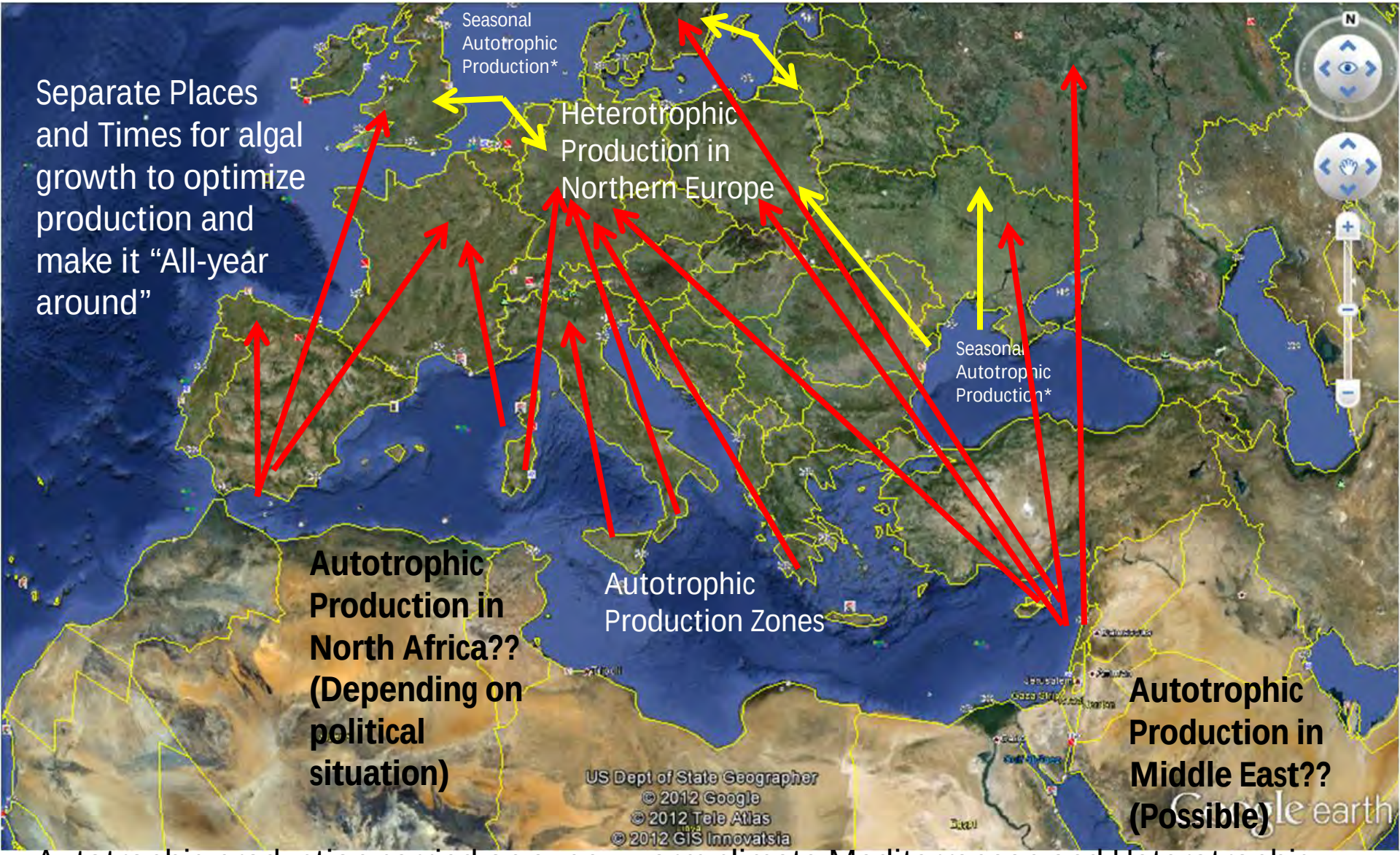
The heterotrophic systems increase the production of lipids by increasing its cell density a dozen times while increasing its fat content from 15 to 55 % by weight. The heterotrophic mode is activated when the algae culture is placed in a fermenter without light, in the presence of Oxygen and a Carbon source. **This can increase the fat content per liter up to 35 times in six days.**



Mode		Lipid (%)	Cell density	Cell growth rate
AP		10-20	< 5 g l^{-1}	< 1 g $l^{-1}d^{-1}$
HF		50-60	> 100 g l^{-1}	> 10 g $l^{-1}d^{-1}$

AP Autotrophic photosynthesis
HF Heterotrophic fermentation

A Plan Specifically Tailored for Northern Latitudes



Autotrophic production carried on sunny-warm climate Mediterranean and Heterotrophic production everywhere with an organic Carbon source (sewage, dairy farms, paper mills, etc).

* Seasonal Autotrophic Production will be carried on in outdoors from April to October

The Heterotrophic biomass is harvested when it is at least 3 grams/Liter with 60% fat content. The Appliance Harvester flocculates, concentrates, lyses and hydrogenate the cells, converting them into the best feedstock for a Hydropyrolisis Refinery. In most cases, we do not need the harvester... the algae over 5 grams/L can be taken with your bare hands.

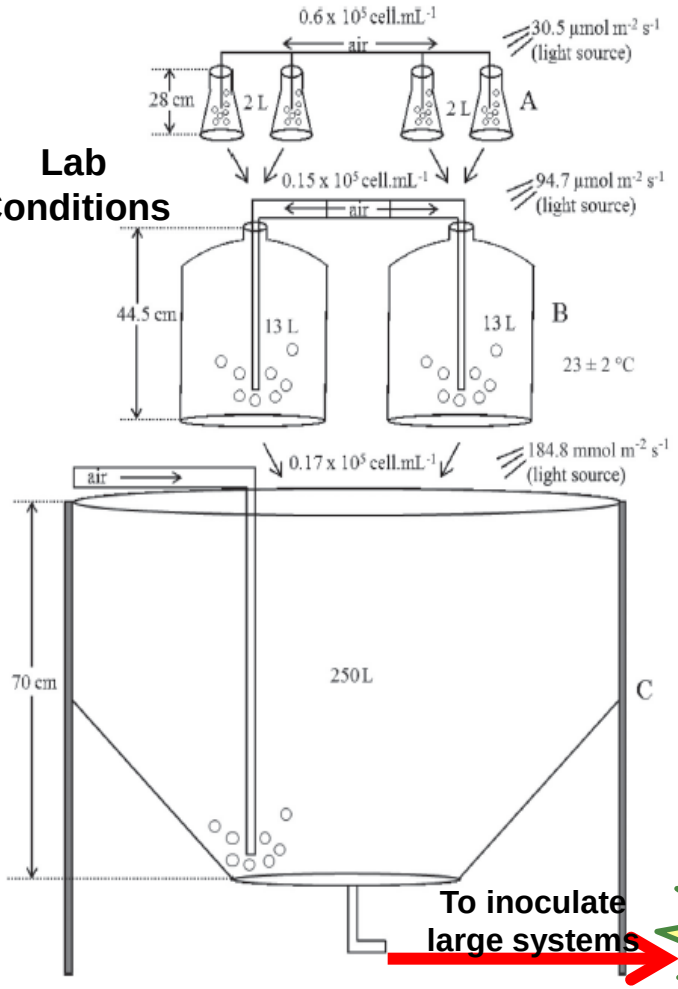
Additional Advantages

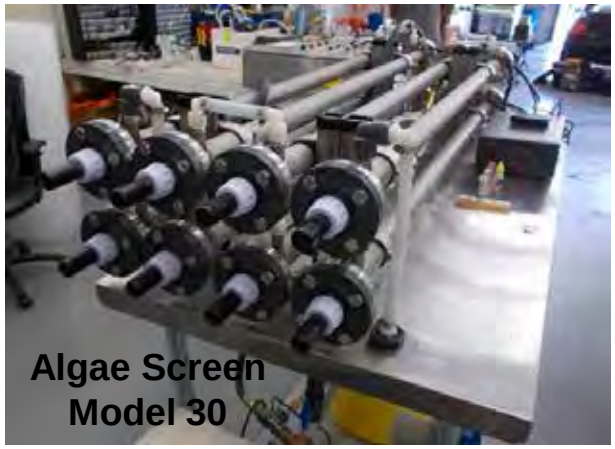
- Promise to Change the Paradigms in Asthaxantin Production:
  - EWS Algae can Harvest HP green cells yielding viable cells for shift
  - EWS Algae can Harvest HP red Cysts and concentrate them
  - EWS Algae EM pulses stress and remove bacteria from HP

We have empirically seen that this concentrated, viable, cleansed and stressed paste of HP green cells once placed inside a stressing reactor induces a more controlled metamorphosis into the red cysts. We have more cells, given that we do not have attacks from predators/bacteria in the green phase; preliminary results show that the cells present faster rates of evolution into cysts. We can harvest the red cysts as well to dry them swiftly

Sounds Familiar?

Lab Conditions





The scale up of Haematococcus in green phase often stops due to crashing as soon as the culture leaves the lab. The use of Algae Screen as it passes to the next level reduces the possibility of crashing, allowing to reach the thousands of liters level required for commercial production.

Additional Advantages

- Clean Growth:
  - OriginOil's Algae Screen™ works on living algae to eliminate most bacteria, rotifers, ciliates and adverse algae
  - Decontaminated algae grows better, demonstrating improved yield at harvest*
  - Degree of improvement exceeds 50%, with potentials exceeding 80%

- Extended Shelf Life:
  - Normally, algae begins to rot after harvesting; short shelf-life complicates yield/ROI
  - EWS Algae decontamination delivers shelf-life up to one month**

* Source: OriginOil Announces Breakthrough Innovation to Increase Algae Yield

** Source: OriginOil Internal Estimate (3rd party study in progress)

In Summary

- EWS Algae is an algae harvesting technology with a high biomass retrieval efficiency, scalable to commercial sizes and with the lowest capital and operational costs per Kg DW algal biomass.

- Frequent harvest of algal biomass is absolutely necessary to keep algae growing in an optimum way. EWS algae controls the translucency of algae cultures, which keeps the cells growing in an exponential mode

- Harvesting with EWS Algae removes bacteria and other microorganisms from harvested algae paste and water effluent. EWS Algae can be used to de-contaminate algae cultures and control microbiology to prevent crashes in production and loss of profits.

- The microbiological control of EWS Algae™ allows producers to increase production by performing “Heterotrophic Jump”, as well as scale up delicate strains such Haematococcus pluvialis.

Thanks

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