# Recovering Microalgae Using a Salsnes Filter


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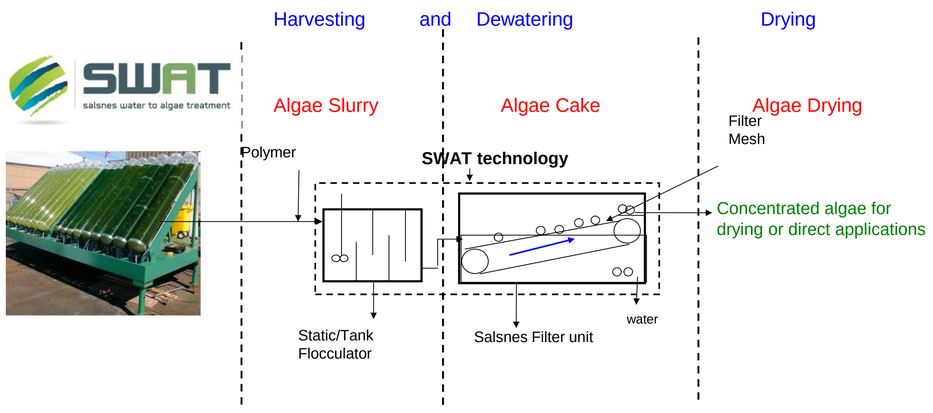
## Introduction & Objectives

- The overall goal is to develop a universal microalgae harvesting technology:
  - by building on the experiences gained from removal of particles from wastewater
  - by modifying the current wastewater technologies such as Salsnes Filter (SF)
- SF has been succesfully used for primary treatment of municipal wastewater
- Aim is to recover >95% of microalgae from water phase and
- use <0.08 kWh/m$^3$ of algae



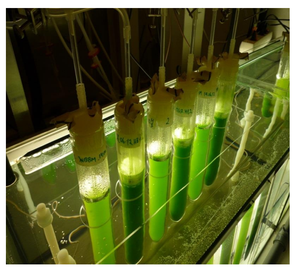

**Salsnes Water to Algae Treatment (SWAT) filter technology**

**The SWAT team**

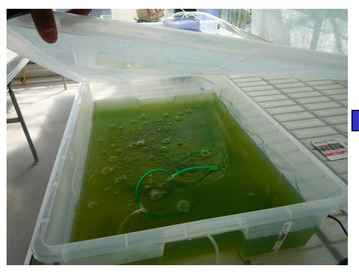
## Methods, Materials, Results

### Culture, grow 5 species, evaluate cell size, growth conditions

**Step 1**



Five algae species cultures

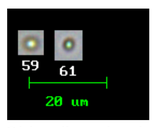


Open air tray photobioreactors natural light + air circulation

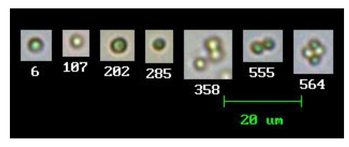
Portable FlowCam device

| Species | Shape | Media | Avg particle size (L) | Number of particles analysed | Area based diameter |
|---|---|---|---|---|---|
| | | | µm | # | µm |
| *Chlorella vulgaris* | Spherical | FW | 5.07 | 3838 | 3.99±1.26 |
| *Dunaliella salina* | Irregular | M | 7.26 | 646 | 4.84±3.7 |
| *N. Oculata* | Spherical | M | 4.8 | 3805 | 3.76±0.94 |
| *Scenedesmus sp* | Rod | FW | 20.01 | 440 | 14.7±6.61 |
| *Wild type* | Oval | WW | 50.43 | 54 | 14.8±7.83 |
| Spirulina plantensis | Spiral | FW | 111.99 | 3179 | 112± 80 (L) 47±36 (W) |

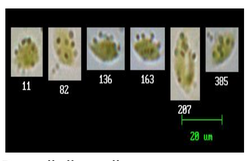
FW- fresh water; M-Marine; WW-Wastewater



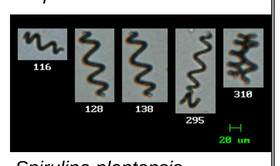

*Chlorella vulgaris*



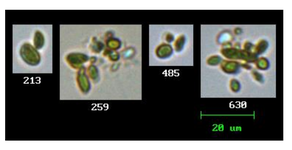

*Nanochloropsis oculata*



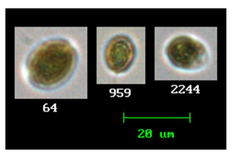

*Dunaliella salina*




*Spirulina plantensis*



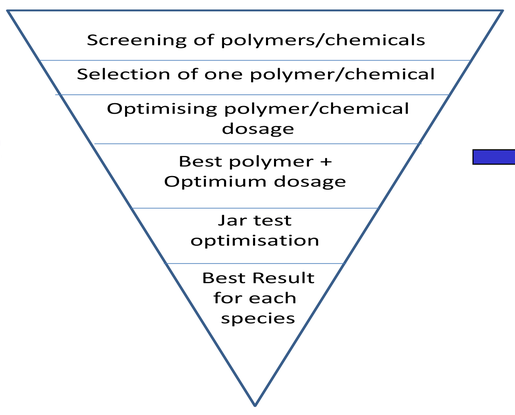

*Scenedesmus sp.*



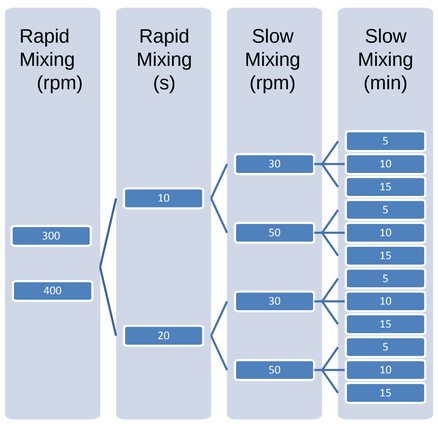

*Wild type sp.*

### Test different polymers + chemicals, determine mixing intensity

**Step 2**




Kemira Jar Test Flocculator



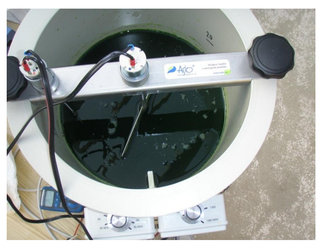

Mixing regimes with optimised dosage

| Species | % Removal of Turbidity | Rapid mixing (300 rpm) | Slow mixing (30-50 rpm) |
|---|---|---|---|
| | | s | min |
| *Chlorella vulgaris* | 95 | 10 | 5 |
| *Dunaliella salina* | 98.8 | 10 | 5 |
| *N. Oculata* | 79 | 20 | 10 |
| *Scenedesmus sp* | 98.9 | 20 | 5 |
| *Wild type* | 64 | 10 | 10 |

### Test different size flocculators, using scaled up G values

20 L tank flocculator

**Step 3**



Bench Scale Asio Flocculator (BSAF)

The power requirements were calculated using Equation 1.This equation was introduced by Camp and Stein (1943) as a measureable average value to replace the local velocity gradient during turbulent mixing.

$$G = \sqrt{\frac{P}{uV}} \qquad \text{(Equation 1)}$$

where

P energy dissipation from mixing (W)
u absolute viscosity of the liquid
V volume of the tank (m$^3$)

For a mechanical mixer, the power consumed by the mixer is given by (Bratby, 2006)

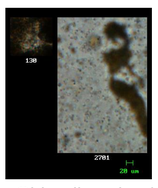
$$P = \varphi \cdot \rho \cdot n3 \cdot D5 \ (\text{Nm/s}) \qquad \text{(Equation 2)}$$

where

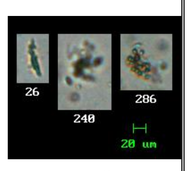
φ dimensionless power number
ρ liquid density (kg/m3)

| | Rapid Mixing | | Slow Mixing | |
|---|---|---|---|---|
| | rpm | s | rpm | Min |
| Jar Test | 300 | 20 | 50 | 5 |
| 20 L | 232 | 20 | 74 | 5 |
| BSAF | 95 | 20 | 30 | 5 |

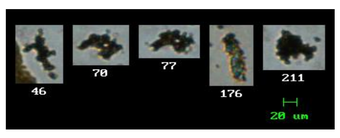
| Species | Avg floc size (L) | Number of flocs analysed | Area based diameter range |
|---|---|---|---|
| | µm | # | Sq. µm |
| *Chlorella vulgaris* | 181.40 | 227 | 72.46±14.24 |
| *Dunaliella salina* | 71.35 | 428 | 41.91±9.85 |
| *N. Oculata* | 59.05 | 2650 | 35.29±8.66 |
| *Scenedesmus sp* | 78.21 | 4499 | 40.73±12.38 |
| *Wild type* | 90.96 | 892 | 52.28±14.49 |



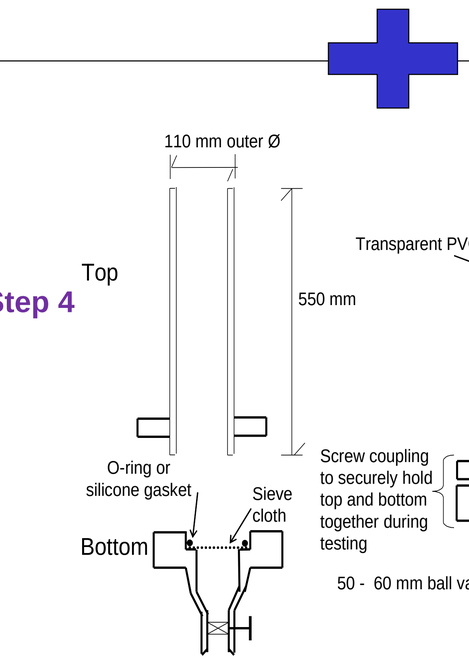

*Chlorella vulgaris*




*D. salina*

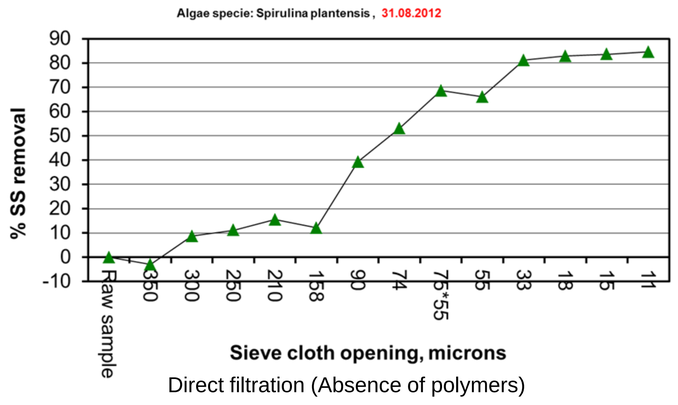



*Nanochlorropsis oculata*




Bench scale Salsnes Filter

**Step 4**


Direct filtration (Absence of polymers)

### Flocculation + Salsnes Filtration = SWAT technology

- Direct filtration results clearly showed that the tested algae species need to be flocculated in to larger particles in order to achieve the goal of 90% recovery when harvested on a filter mesh sieve
- Optimum flocculant and optimum dose is very dependent on the type of algae
- Very good flocculation could be achieved with all the tested algae species, but for some species it may not be achieved at an economically acceptable chemical dose
- Bench scale flocculation and Salsnes filtration resulted in 93 % and 96 % recovery of *Chlorella vulgaris* and *Scenedesmus sp,* respectively. *Results based on TSS*
- Pilot scale flocculation (20 L) and Salsnes filtration resulted in 92 % and 84% recovery of *Nanochloropsis oculata* and *Wild type sp*, respectively. Results based on TSS.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