Bio-based technologies for microalgae harvesting

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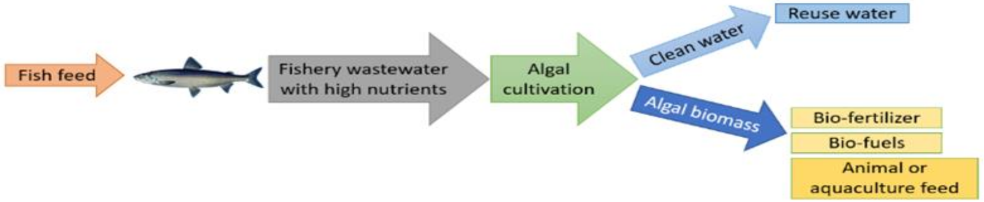
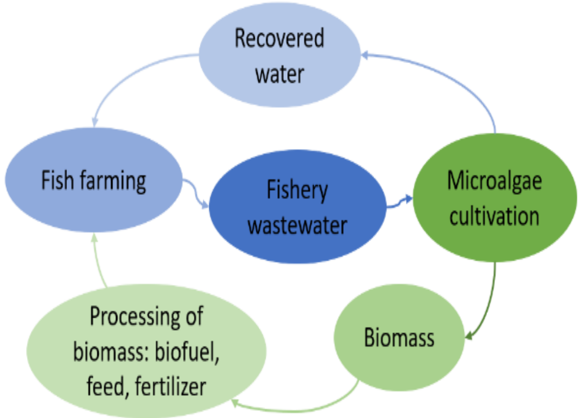
Integration microalgae production with wastewater treatment (WWT)

- Microalgae can remove phosphate and nitrogen from wastewater.
- These nutrients can be absorbed by algal cell biomass and then treat wastewater.
- Algae cultivation in wastewater has the dual benefit of cleaning the wastewater while also producing algal biomass.
- Therefore, effcient biomass recovery or harvesting of diverse algal species represents a critical bottleneck for large-scale algal biorefinery process.





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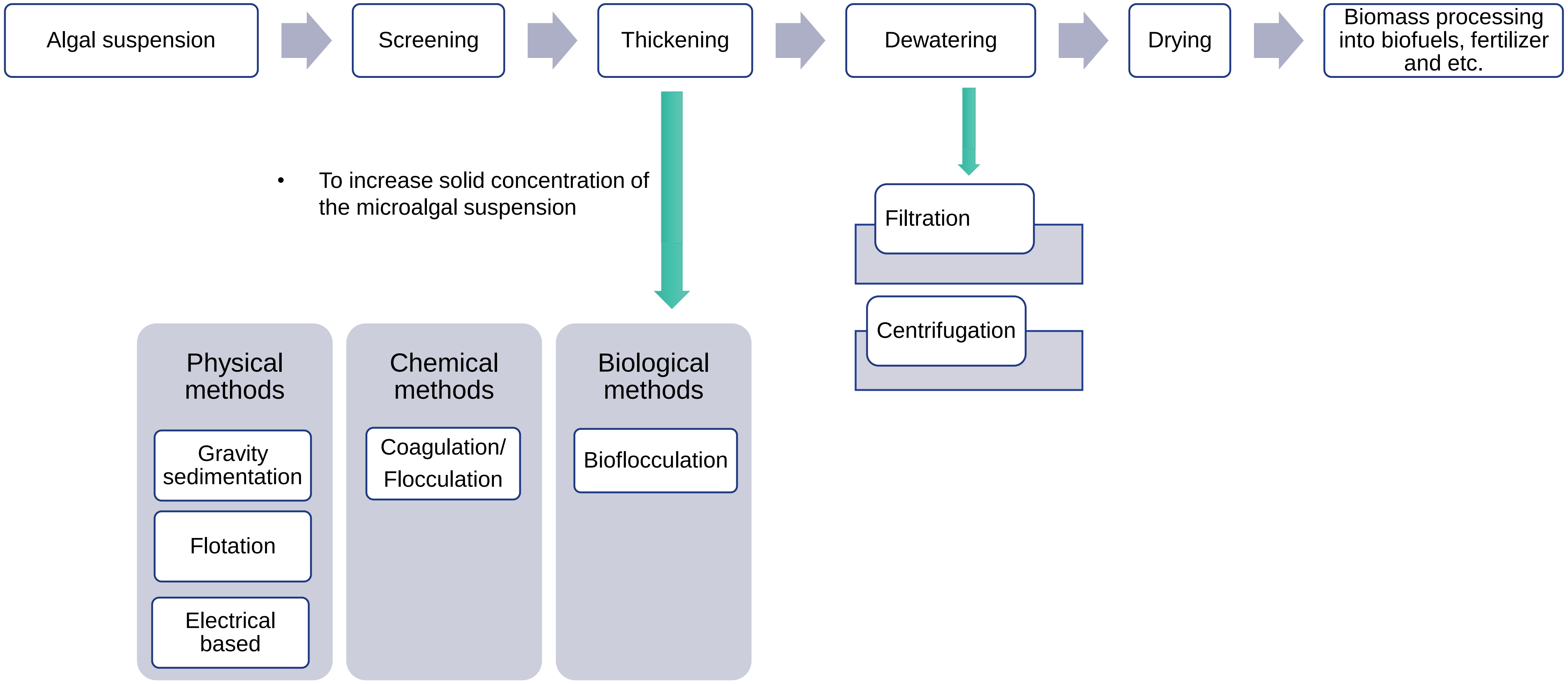
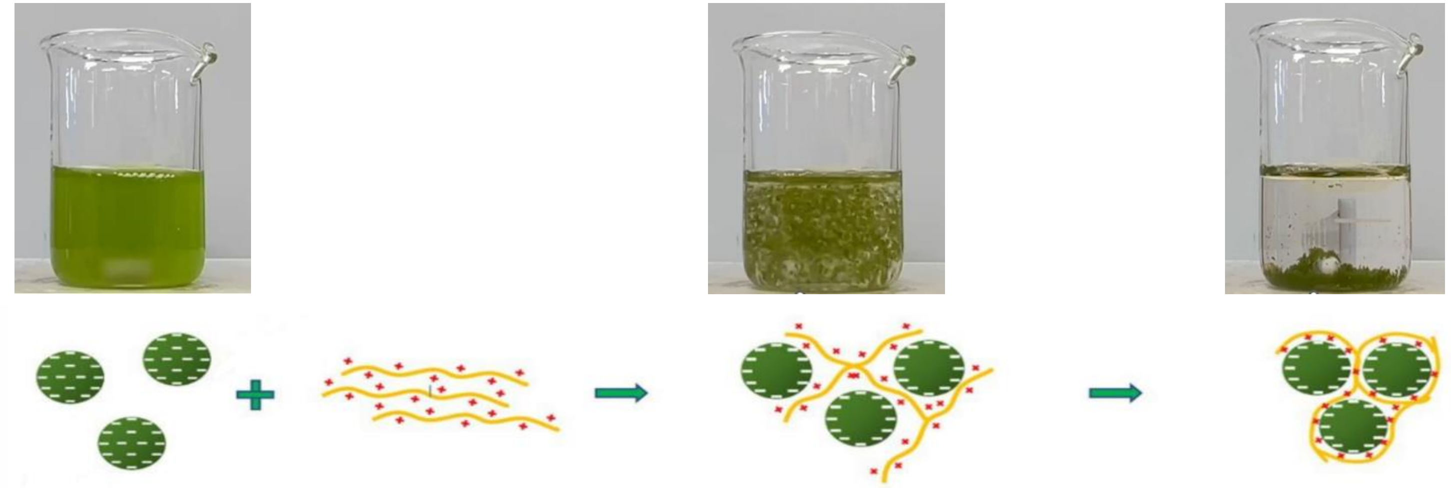
Microalgae harvesting methods:



Harvesting method	Description	Advantages	Disadvantages
Gravity sedimentation	Microalgae settle by to gravity.	• Simple and inexpensive.	• Time-consuming. • Possibility of biomass deterioration. • Low concentration of the algal cake.
Flotation	Gas bubbles fed to the broth provide the lifting force needed for particle transport and separation	• Feasible for large scale applications. • Low-cost method. • Short operation times.	• Requires the use of chemical flocculants. • Unfeasible for marine microalgae harvesting.
Electrical based processes	An electrical field is applied to the culture broth	• Applicable to a wide variety of microalgal species. • Do not require the addition of chemical flocculants	• Poorly disseminated. • High energy and equipment costs.
Chemical coagulation/ flocculation	Use of chemical reagents (organic (chitosan, tannin) or inorganic (Alum, iron-based) to destabilise and increase the size of the particles	• Simple and fast method. • Low energy requirements.	• Can be expensive. • Recycling of culture medium is limited.
Auto and bioflocculation	• Flocculation by pH increase • Flocculation by fungi, bacteria, yeast, algae, extracellular polymer	• Inexpensive method. • Allows culture medium recycling. • Non-toxic to microalgal biomass.	• Changes in cellular composition. • Possibility of microbiological contamination.
Filtration	Microalgal deposits on the filtration membrane tend to grow thicker throughout the process	• High recovery efficiencies. • Allows the separation of shear sensitive species.	• The possibility of fouling/clogging • Regularly cleaned/replaced
Centrifugation	Spinning algal broth at high speed	• Fast method. • High recovery efficiencies.	• Expensive method. • High energy requirements. • Possibility of cell damage due to high shear forces.

Coagulation-flocculation harvesting process of algal cells :

- Coagulation is charges' neutralization and flocculation refers to agglomeration of unstable and small particles through surface charge neutralization, electrostatic patching and/or bridging.
- Flocs formation allows for separation (or recovery) by simple gravity-induced settling or any other conventional separation method.
- The process is simple and efficient and has been extensively investigated as a promising strategy for harvesting various algal species.
- Optical Density Measurement: how much light is absorbed or scattered by a solution. In this context, optical density can provide information about the concentration of particles or flocs present in the treated suspension.



Jar Test Setup:

Rapid Mixing:
- Agitation speed set at around 200 rpm for 30 seconds.
- Purpose: Ensures uniform distribution of coagulant throughout the suspension.

Coagulant Addition:
- Coagulant was added during rapid mixing phase.

Slow Mixing:
- Agitation speed reduced to approximately 20 rpm for 10 minutes.
- Objective: Encourages the formation of larger flocs from the coagulated particles.

Settling Phase:
- 30-minute period with no agitation.
- Force of gravity causes larger flocs to settle towards the bottom.
- Extract samples from the liquid's surface for measuring optical density.

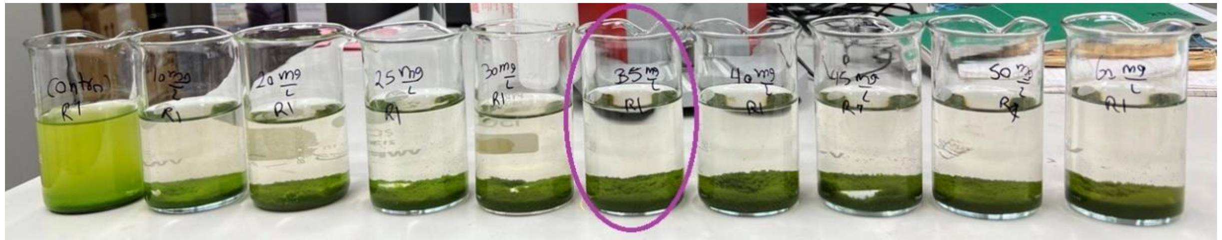
The video playback speed was increased to 2x.

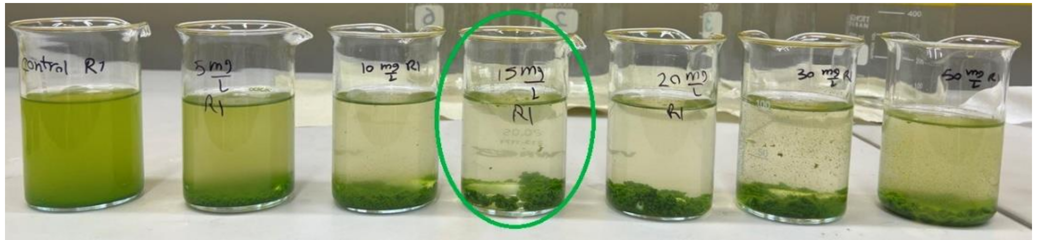
Chemical flocculation with tannin and chitosan - optimum dosage:

Sample Collection:

- Microalgae samples (Chlorella.S) obtained from Micropolis Oy for testing.
- A 100 ml suspension of microalgae placed in a beaker as the testing medium.

Result: Optimum dosage of chitosan was 15 mg/l and for tannin was 35 mg/l with harvesting efficiency of 97% and 99%, respectively.





Chemical flocculation with tannin and chitosan - settling rate:

Sample Collection:
- Chlorella.S microalgae samples sourced from Micropolis Oy.
- 800 ml of microalgae suspension poured into a 1000 ml beaker.

Result: At optimal doses, settling rates were similar with both coagulants.

Effect of pH on microalgae flocculation

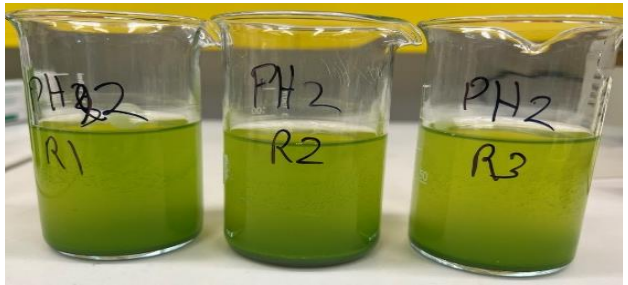
Sample Collection:

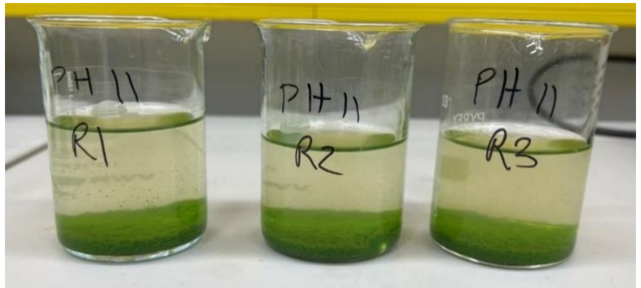
- Chlorella.S microalgae samples sourced from Micropolis Oy.

pH Adjustment:

- Used 1M HCl (hydrochloric acid) and 1M NaOH (sodium hydroxide) solutions.
- pH adjusted to the desired level for experimental conditions.

Result: Higher pH increased auto-flocculation of algae (but can affect the dissolution of protein – pH adjustment not feasible)





Chemical flocculation with tannin after fish processing wastewater treatment with microalgae:

Microalgae was added to fish processing wastewater:

- Microalgae initially added to fish processing wastewater.
- Optical density measurements taken after 10 and 15 days of microalgae introduction.

Evaluation timeline:
Day 10 and Day 15 evaluation:

- Wastewater samples analyzed on day 10 and day 15 after tannin coagulation.
- Comparison of characteristics before and after coagulant addition.

Results: Optimum tannin dosage was 60 mg/l with optical density of 0.066 and 0.058 on day 10 and day 15, respectively.

Bio-flocculation with fungus:

Mutual Enhancement:

- Fungi consumes carbon produced by the microalgae in the medium via photosynthesis.
- Microalgae are provided with protection by the fungi.

Fungal Strain (F. solani):

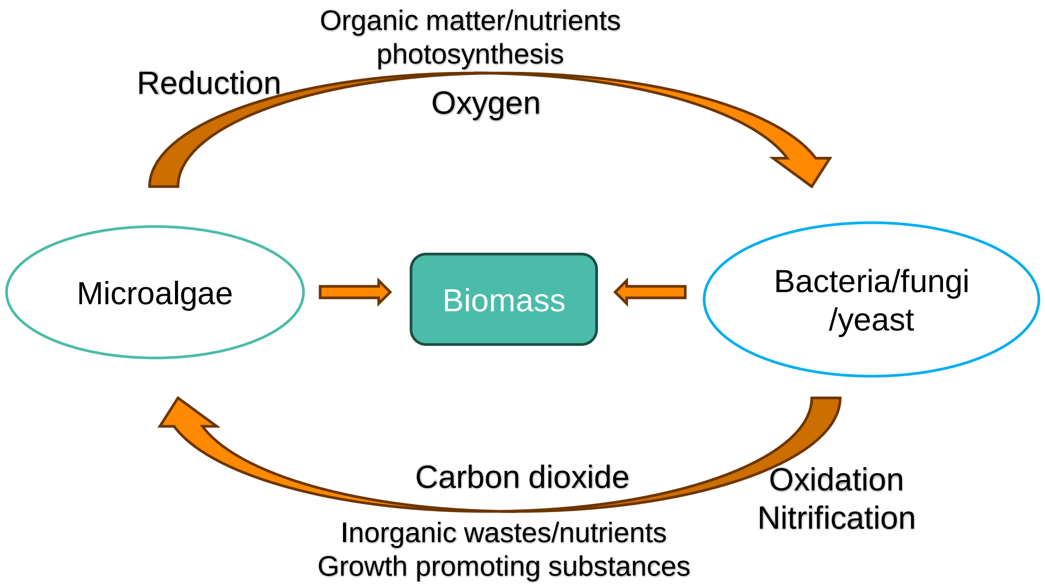
- Sourced from VTT culture collection, Finland.
- Cultivated for stability on plates and in bottles.

Experiment Focus:

- Studied microalgae/fungi and wastewater/fungi symbiosis.
- Investigated potential benefits for wastewater treatment.

Future Pathways:

- Building on co-culture insights.
- Exploring wider applications and process refinement.



Synergic effect between fungus and microalgae – adding carbon source:

Enhancing Collaboration:

- Investigating the synergy between fungi and microalgae with the ratio of 1/100.
- Introducing additional carbon source (glucose and glycerol) to optimize effects.

Mutual Benefits:

- Microalgae use added carbon for growth and photosynthesis.
- Fungi benefit from enhanced carbon availability.

Result: Adding glycerol as a carbon source could enhance the synergic between algae and fungus.

Name	TN	TP
Control (Chlorella.S)	18.8	33.3
A/F= 100/1	21.5	34
A/F= 100/1 + glucose	8.34	31.3
A/F= 100/1 + glycerol	6.36	29.6

Synergic effect between fungus and wastewater – adding carbon source:

Investigating Synergy:

- Exploring combined impact of fungus and wastewater.
- Focusing on the addition of a carbon source.

Beneficial Symbiosis:

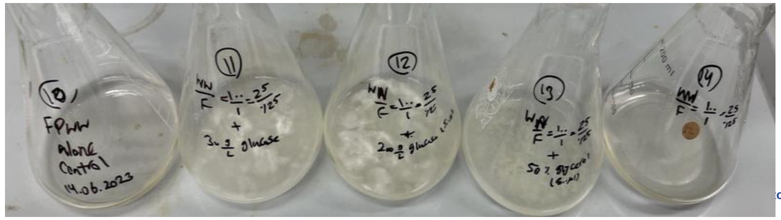
- Fungi thrive on carbon compounds.
- Wastewater environment benefits from fungal activities.

Practical Implications:

- Enhanced wastewater treatment potential.
- Insights for optimizing fungal-wastewater interactions.

Result: Adding glucose as a carbon source could enhance the synergic between wastewater and fungus.

Name	TN	TP
Control (FPWW)	52.6	19.1
W/F= 100/1 (spore)	58.7	18.5
W/F= 100/1 (spore) + glucose	12.5	1.26
W/F= 100/1 (spore) + glycerol	12.8	5.78



Conclusions:

Effective and Sustainable Solutions:

- Bio-based technologies offer effective microalgae harvesting methods.
- Harness natural processes for separation, reducing energy consumption.
- Promote sustainability by minimizing chemical and energy inputs.

Diverse Applicability and Scalability:

- Bio-based methods adaptable to various microalgae species and environments.
- Potential for scalable implementation in both small and large operations.
- Address challenges of traditional methods, making harvesting feasible.

Pathway to Green Innovation:

- Bio-based approaches align with green and eco-friendly principles.
- Reflect growing interest in sustainable practices in various industries.
- Open doors for innovation and collaboration in biotechnology and beyond.

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Thank you for your attention!