Harvesting of microalgae culture

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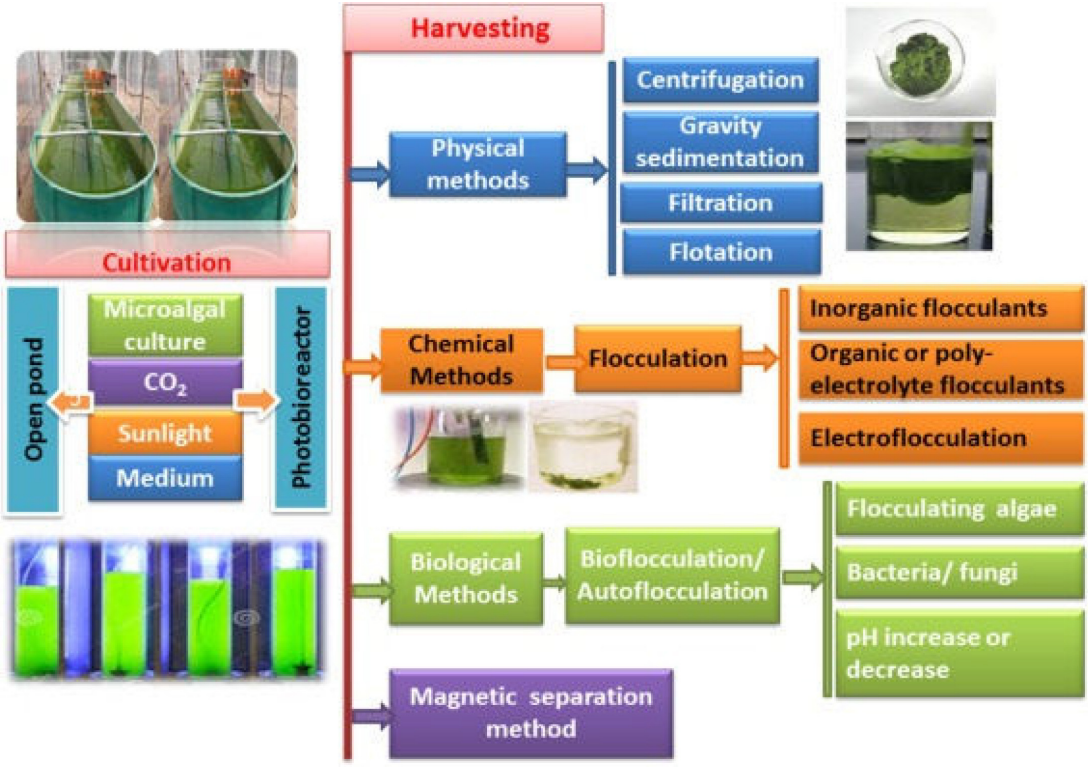
Finfish / Shellfish hatcheries typically use large quantities of single-cell phytoplankton (microalgae) to feed shellfish larvae. Microalgae are enriched with a variety of high-value compounds natural pigments, anti-oxidants, vitamins, minerals, polysaccharide, and so on. Algae production requires hatcheries to commit large square footage and equipment cost to culturing phytoplankton. Additionally, culturing algae requires committing significant labor and other operating costs to maintain algal cultures and equipment. The current microalgal production technologies are not cost-effective and are hindered by various bottlenecks, one of which is the harvesting of microalgal biomass. After cultivation of microalgae on a large scale, there is a need to reduce the volume for concentrating the microalgal cells. The development of microalgae concentrates for feeding larvae provides the opportunity to mitigate significant capital and operational costs.

The culture should be harvested during the exponential phase of the micro-algae after determining the cell concentration. If the culture has entered the declining or stationary phase, the metabolites will be very high and the cells may not be in healthy condition. Rearing larval organisms or zooplankton may not show the expected growth if fed with this feed. The trouble which comes frequently like air pressure, salinity, pH, culture contamination, nutrient media for culturing the algae needs immediate attention. Frequent observation to avoid contamination is essential as the algal feed is very much important in terms of nutrients for the other organisms like rotifers and copepods to feed on and also pure culture should not be contaminated while adopting the green water technology for the larval rearing system for marine fishes or shell fishes.

Harvesting techniques

For the commercialization of microalgal products, it is very important to harvest the microalgal biomass effectively in a low-cost manner. The effectiveness of microalgal harvesting mainly depends on achieving high biomass production with low operation cost, maintenance, and energy. Most of the harvesting stages are costly followed by downstream processing. The selection of specific harvesting methods will mainly depend on the end products and should consider the cell size

and density, cell damage, salt concentration, and moisture content. During harvesting, it is important to avoid the chances of contamination and the possibility of culture medium recycling should also be taken into consideration. The currently available methods are based on chemical, biological, mechanical, and electrical technologies. For low-cost biomass harvesting methods combination of two or more methods can be employed. The significant downstream processing carrying the combined effects of flocculation, followed by sedimentation with centrifugation could be employed to minimize the cost of processing. Biological methods are also considered as a low-cost method because of the low operational cost along with different mechanical processes.



Various methods used for microalgal biomass harvesting
(Source:https://www.sciencedirect.com/topics/engineering/algal-harvesting)

Advantages and disadvantages of algae harvesting

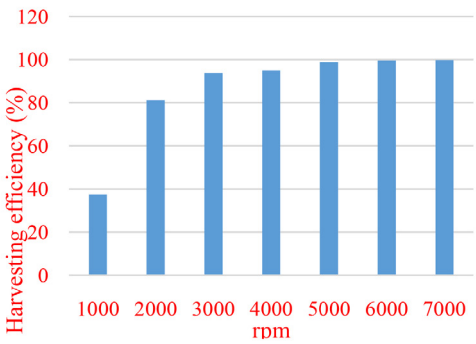
Technique	Advantages	Disadvantages
Coagulation/ flocculation	▸ Fast and easy technique ▸ Large scale usage ▸ Less cell damage ▸ Applied to vast range of species ▸ Less energy requirements ▸ Auto and bioflocculation may be inexpensive methods	▸ Chemicals may be expensive ▸ Highly pH dependent ▸ Difficult to separate the coagulant from harvested biomass ▸ Efficiency depends upon the coagulant used ▸ Culture medium recycling is limited ▸ Possibility of mineral or microbial contamination
Flotation	▸ Suitable for large scale ▸ Low cost and low space requirement ▸ Short operation time	▸ Needs surfactants ▸ Ozoflotation is expensive
Electrical-based processes	▸ Applicable to all microalgal species ▸ No chemical required	▸ Metal electrodes required ▸ High energy and equipment costs ▸ Metal contamination
Filtration	▸ High recovery efficiency Cost-effective ▸ No chemical required ▸ Low energy consumption ▸ Low shear stress ▸ Water recycles	▸ Slow, requires pressure or vacuum ▸ Not suitable for small algae ▸ Membrane fouling/clogging ▸ High operational and maintenance cost ▸ High energy consumption
Centrifugation	▸ Fast and effective technique ▸ High recovery efficiency ▸ Preferred for small scale and laboratory ▸ Application to all microalgae	▸ Expensive technique with high energy requirement ▸ High operational and maintenance cost ▸ Appropriate for recovery of high-valued products ▸ Time consuming and too expensive for large scale ▸ Risk of cell destruction

Case Study 1: Evaluation of efficiency of different harvesting techniques on microalgae *Nannochloropsis oculata*

(i) Centrifugation:

Harvesting of *Nannochloropsis* by Centrifugation

Harvesting of the *Nannochloropsis* culture in growing phase/log phase by centrifugation at 7000 rpm for 5 minutes at 4^0Cresulted in harvesting efficiency of 99.6%. Followed by preservation with different doses of glycerol (5 to 20%) in different storage method results that the preservation of the harvested *Nannochloropsis* by the mode of chilling can perform better than by freezing counterparts in terms of its efficiency as stock culture in the future. Microalgal concentrate is an alternative approach to ensure all-time availability of sufficient quantities of micro algae for larval rearing and zooplankton culture. Micro-algal concentrates are prepared and preserved with added preservatives and this could be used at the time of requirements. Major advantage of *Nannochloropsis oculata* concentrate (**NANNCON-** ICAR – CMFRI) with a cell count of 30billions/ml compared to other commercial products include, cell viability more than 80% even after five months of storage in glycerol under chilled conditions. The concentrated cells perform as inoculums, after dilution, for mass scale culture as well as direct feed to rotifers.

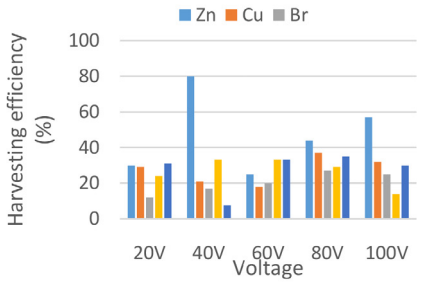


(ii) Electroflocculation:

Different electrodes : Aluminum, Zinc, Copper, Brass and Iron as both anode and cathode

Different voltages viz; 20,40,60,80 and 100 V at constant power (90mA) and time (30 minutes).

Zinc electrodes performed better with 80% harvesting efficiency at 40V

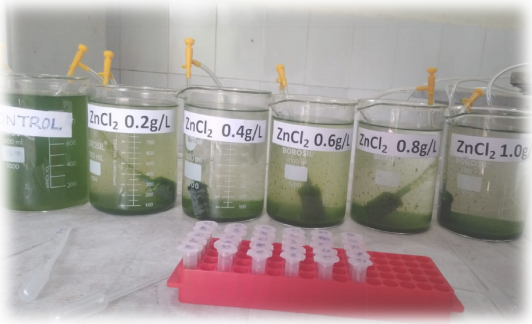


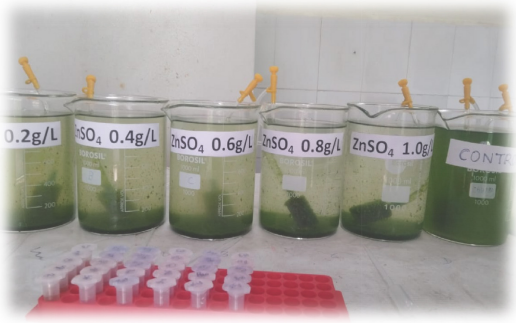
(iii) Chemical flocculation:

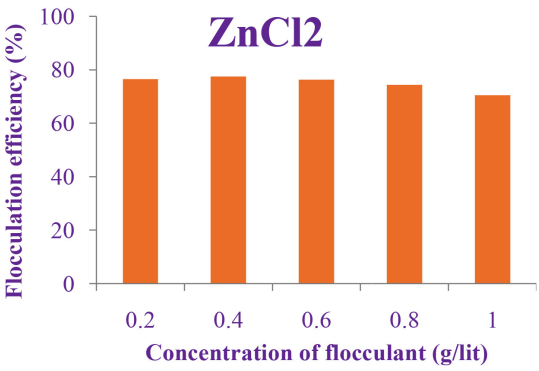
$ZnCl_2$and $ZnSO_4$ (02, 0.4, 0.6, 0.8 & 1.0g/lit)

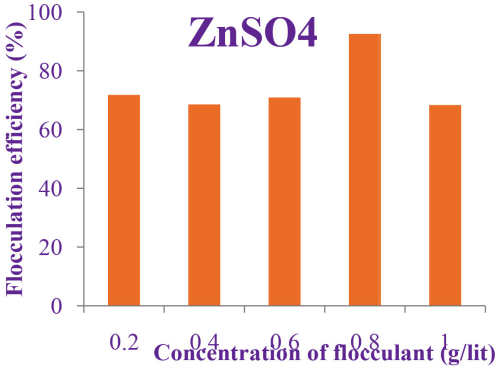
Zn SO_4 with 0.8gm/lit of *Nannochloropsis* culture performed better with 92% of harvesting efficiency

$ZnCl_2$, the harvesting efficiency was varied from 70.55 % -77.54 %



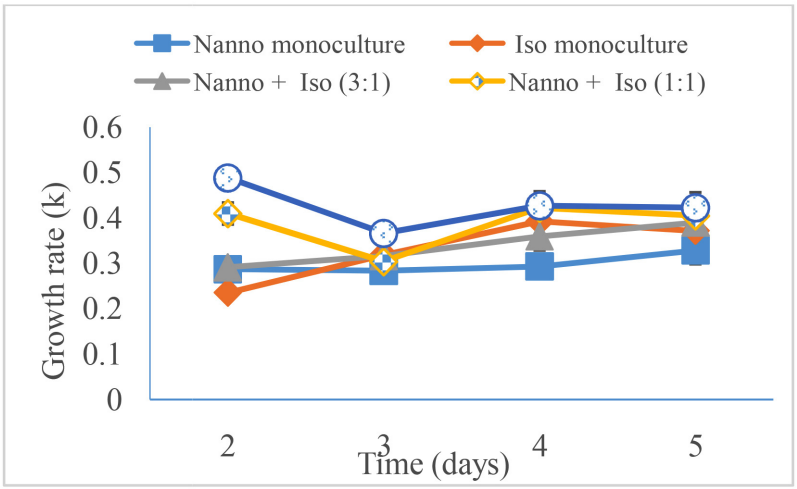






Case Study 2: Comparative study on growth performance of mixed cultures of marine microalgae (*Nannochloropsis* sp. &*Isochrysis* sp.) with monocultures

The growth rateand total lipid content were highest in mixed culture ratio of 1:3 with *Nannochloropsis* and *Isochrysis* resp. The study indicates that mixed culture of microalgae as an alternative option for commercial microalgal production to obtain higher production.



Case Study 3. *Nannochloropsis oculata* concentrate (NANN CON)

Case Study 4: pH induced flocculation of *Chaetoceros calcitrans*

Flocculation of *Chaetoceros*culture with adjustment of pH using5N NaOH concluded, that induced pH of 10.2 is optimum with better flocculation efficiency for the harvesting of *Chaetoceroscalcitrans*. The induced pH for the flocculation study varied from 8.4 – 11.9.

References

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