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Algae and duckweed offer sustainable solutions to mitigate impacts of water and food insecurity

Simrat Kaur[1*], Brad Reddersen[2], Tim Loncarich[3]

1. Climate Survival Solutions (CSS) India Private Ltd, West Bengal, India, 2. CSS, Cebu, Philippines, 3. CSS, Nova Scotia, Canada

* kaursimrat.drl@gmail.com

INTRODUCTION & AIM

Water & food insecurities are global concerns. Under the Sustainable Development Goals 2 & 6, which are zero hunger & clean water and sanitation, the United Nations have urged the world to utilize available resources, technologies & knowledge at the community levels to close the gap that still exists between goals & the global reality.

Aim: We at Climate Survival Solutions have taken on both the goals to rediscover the potential of the photosynthetic freshwater algae & free floating aquatic plants commonly called duckweeds as biological systems which remove inorganic nitrogen & phosphorous from wastewaters.

Besides water remediation bioprocess, we are farming duckweed *Wolffia globosa* (Monocotyledoneae, Arales, Araceae) as complementary food solutions for humans & as protein rich alternative to soybean (to replace it from both humans & animals diets).

METHOD

Plant Sample Collections

Geographical Locations (microalgae & Lemna): Wetlands, paddy fields, aquaculture &, recreational ponds in Darjeeling district, foothills of Eastern Himalayas, West Bengal, India.

Fig. 1 Collection of water samples from wetlands, fishery ponds (blooming with *Euglena & Botryococcus) & lakes for microalgae isolation & duckweed sampling*

Wastewater treatment (microalgae)- 'Mesocosm studies'

Type 1: using synthetic wastewater medium

Type 2: using natural wastewater from fisheries/village ponds

Duckweed cultivation & *Wolffia globosa* farming

*Species of **Lemna** minor & **Spirodella** are maintained as laboratory feedstock cultures in small & medium size buckets- Experiments on nutrient recovery from wastewaters is under progress.*

***Wolffia globosa:** tank cultivation under natural light with additional LEDs (when required) in optimized nutrient solution under room temperatures*

RESULTS & DISCUSSION

Various spp of microalgae have been isolated

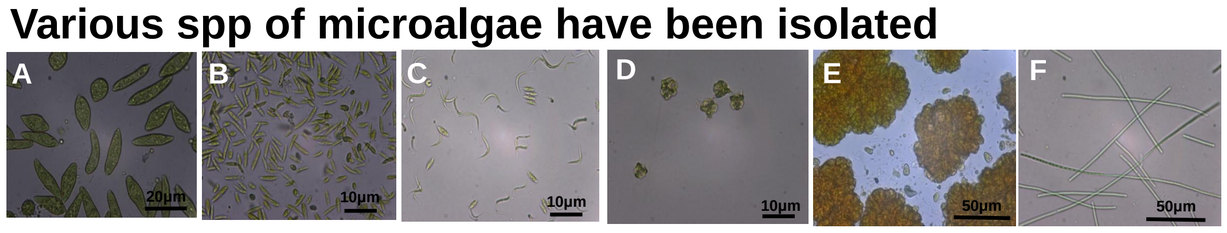


Fig. 2 A-F Micrographs of isolated microalgae. A: *Euglena* sp. B: *Scenedesmus* sp. C: *Ankistrodesmus* sp, D: Unidentified sp of Conjugales E: *Botryococcus brauni* F: *Oscillatoria* sp.

N & P removal from synthetic wastewater using *Oscillatoria* sp.

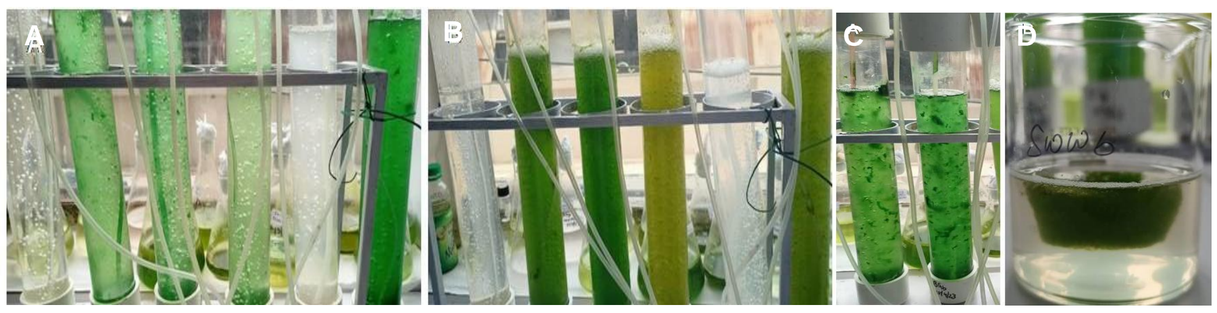


Fig. 3 A-D Bioprocess of removing N & P from synthetic wastewater using *Oscillatoria* sp in tubular photobioreactor under natural light & temperature conditions. A: 3 days of growth, B: 10 days of growth, C: mat formation by *Oscillatoria*, D: autofloatation

Reactor tube	BG control	SWW control	BG	SWW
Biomass productivity (g/L/day)*	nil	nil	0.05 ± 0.007	0.065 ± 0.021
NO_3 (mg/L)*	83.5	76	6.3 ± 2.12	5.3 ± 2.26
NO_3-N (mg/L)*	19	17	1.4 ± 0.56	1.2 ± 0.56
NO_3 (% removal)	NA	NA	92.45	93.02
PO_4 (mg/L)*	23	51	8.2 ± 1.7	3 ± 0.57
P (mg/L)*	7	17	2.6 ± 0.56	1.0 ± 0.28
PO4 (% removal)	NA	NA	64.34	94.11

Table 1: Comparison of nutrient removal efficiencies of *Oscillatoria* in control nutrient medium & synthetic wastewater. BG (standard algae medium) and SWW (synthetic wastewater) control represent reactor tubes that were not inoculated with any algae (to examine algae specific reductions in the nutrient levels).

- carried under natural light & temperature conditions
- to mimic outdoor conditions prevailing for wastewater treatment process or as in open ponds, no sterile environment was provided & contamination by zooplanktons were allowed
- Autofloatation allowed easy & manual harvesting (make process sustainable)
- Harvested *Oscillatoria* was rich in Myristoleic acid (14:1), Myristic acid (14:0), Palmitic (16:0), Palmitoleic acid (16:1) fatty acids.

Duckweed cultivation studies (on-going)

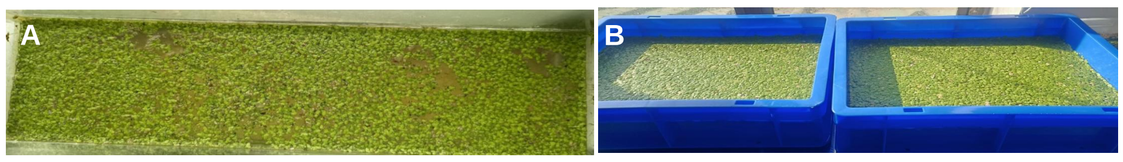
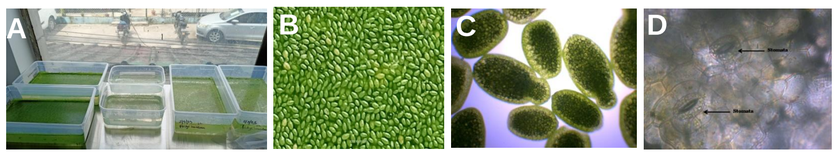


Fig. 4 A-B Cultivation of different members of duckweeds. A: *Lemna minor*, B: *Spirodella* sp.

Wolffia globosa- protein rich food for humans & chicken feed

❑ Nutrient medium optimization



Growth Parameters under natural light & temperature conditions :
TDS- 117-125 ppm; EC- 235-250; NO^{-}_{3}- 97 ppm, PO^{3-}_{4}- 19 ppm

Fig. 5 A-D Wolffia globosa. A: grown in dilutions of nutrient medium, B: Macro view, C: Fronds under microscope, D: Stomata on the fronds

❑ Tank cultivation & nutrient composition

Microalgae free farming of *W. globosa* under natural light & temperature conditions

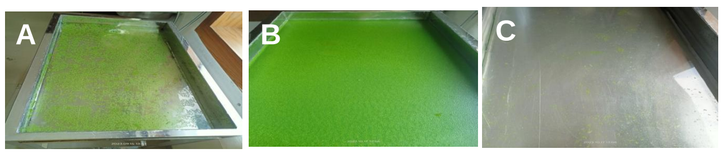


Fig. 6 A-C. Tank cultivation of *Wolffia globosa*. A: starting day, B: day of harvest, C: water in tank after harvest is free of fouling & undesirable biological contaminations

Growth productivities range from **37- 42 g/m²/day** in the months of December & May

Nutritional value of *W. globosa:* Carbohydrates: 30.9% (DW), ***Proteins: 41.2 % (DW),*** Fats: 6.25% (DW)

CONCLUSION

✓**Cosmopolitan blue green alga *Oscillatoria* sp recovered >90% of both N & P from wastewater within a week & due to its characteristic property of autofloatation, it represent one of the most sustainable bioresource for wastewater treatment.**

✓ ***Wolffia globosa* containing >40% dry weight protein represent the most sustainable vegetarian protein source for humans & can replace unsustainable soy based feeds for livestock.**

FUTURE WORK / REFERENCES

• Kaur S, Reddersen B, Loncharich T. Removal of Nitrogen and Phosphorous from Synthetic Wastewater by Oscillatoria sp. Cultivated in Vertical Tubular Photobioreactor under Natural Environmental Conditions. Applied Microbiology: Theory & Technology [Internet]. 2023 Nov. 24 [cited 2024 Jan. 9];4(2):113-2. Available from: https://ojs.wiserpub.com/index.php/AMTT/article/view/3327)

• https://wolffia.link/, https://climatesurvivalsolutions.com/