

Post decomposition effect of water hyacinth on marine phytoplankton - A laboratory study

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Solutions obtained from post decomposition of different parts of water hyacinth were diluted with filtered seawater into different concentration (10%, 40%, and 60%) and used for the culture of *Skeletonema costatum* and *Thalassiosira subtilis*. The solutions significantly affected the biomass growth of *S. costatum* and *T. subtilis*. Highest growth of *S. costatum* was recorded in leaf decomposed solution followed by petiole decomposed solution. High biomass growth of *T. subtilis* was recorded in the culture containing solution obtained from decomposed root. The diluted solution (40%) obtained from decomposed leaf significantly affected *S. costatum* growth (39.3 mg.l^{-1}) after 3 days, while the diluted solution (10%) of decomposed root showed significant growth of *T. subtilis* (8.5 mg.l^{-1}) after 5 days. High biomass growth of the culture might be due to high nutrients, such as nitrogen, phosphate and silicate content in the solution. Considering the bloom forming nature of this phytoplankton species and its ability to take advantage of transient nutrient flux, the study indicated a high probability of bloom occurring post macrophyte decomposition.

[Keywords: *Eichhornia crassipes*, *Skeletonema costatum*, *Thalassiosira subtilis*, Culture, Decomposed solution, Total organic carbon (TOC), Nutrient]

Introduction

The decomposition process enables the mineral cycling in an ecosystem. Besides the release of large quantity of nutrients and organic matter from the decaying biomass, the decomposition of aquatic plants after growing season exert heavy demands on the oxygen resources of a water body¹.

Water hyacinth [*Eichhornia crassipes* (Mart.) Solms] is considered as one of the world's worst aquatic weeds² and a nuisance³ due to its fast growing and rapid spreading nature, and deterioration of aquatic system. In Cochin backwater/estuary, heavy growth of macrophyte especially water hyacinth, occurs during monsoon due to the high precipitation and the influx of freshwater from the riverine system. However, soon after monsoon the macrophytes start dying due to the intrusion of seawater. This seasonal phenomenon generates great amount of detrital matter due to the decomposition of the water hyacinth (Authors' observation).

Besides the macrophyte, phytoplankton are the other primary producers in an aquatic system, providing the important link to higher trophic level. They are responsible for the process that sustains the aquatic food web. However, changes in various

environmental parameters are known to affect the growth of phytoplankton. The high phytoplankton biomass in the Cochin estuary was attributed to the high nutrients input from the industries, agriculture and domestic sources⁴. Water hyacinth was also reported to affect the productivity of lakes physically through its shading effect^{5,6,7}; though no change in the species composition of phytoplankton due to the presence of water hyacinth⁸. On the contrary, the knowledge of whether the macrophyte plays any chemical role on the aquatic productivity through its decomposition process or not is limited. In addition, the estuary acts as a sink for the nutrients and other pollutants, flushing out only a portion of it that it receives⁹. In view of this, effort was made to understand the implication of water hyacinth decomposition on the phytoplankton biomass by designing a laboratory study. Present study is to evaluate the phytoplankton response to the decomposition of water hyacinth and the extent of its effect on the biomass growth.

Materials and Methods

Different parts of water hyacinth (leaf, petioles and roots) of known weight (~25 gm wet weight) were

subjected to decomposition in 1L (v/v) double distilled water for ca four months under dark condition. It will be referred to as solution/s, hereafter. The decomposition rate of different plant parts ranged from 0.002 – 0.09 mg⁻¹ g⁻¹ day⁻¹. Solution obtained from different plant parts were filtered through 100 µm mesh. The initial total organic carbon (TOC) and nutrient concentrations were measured (Table 1) and the samples were stored at 4°C until use for phytoplankton culture experiments. Prior to the culture, the decomposed solution was again filtered through GF/F filter paper (Whatman, 0.7 µm pore size).

Phytoplankton species, *Nitzschia clostridium*, *Skeletonema costatum*, and *Thalassiosira subtilis* are the most abundant members in Cochin backwaters^{4,10}. To evaluate the implication of water hyacinth decomposition on the productivity, two commonly occurring species viz. *Skeletonema costatum* and *Thalassiosira subtilis* were collected and tested for their response under the laboratory conditions. The solution from the decomposition of different parts of water hyacinth were diluted with filtered aged seawater (0.22 µm; nutrients concentration was negligible) into three different concentrations (10%, 40%, and 60%) in the experimental setup. Filtered fresh seawater (0.22 µm) was used as control. The duration of experiment was for a period of 7 days. The cultures were first acclimatized in different levels (80 and 50%, in order) of F/2 culture medium prior to use in the test. The cultures were maintained under an ambient light condition of 18 µmoles.m⁻².sec⁻¹, 14/10 photoperiod at room temperature of 23 ± 2°C and the salinity was maintained at 30 psu. The effect of solution post decomposition on the growth of phytoplankton was measured in terms of chlorophyll *a* concentration (mg.l⁻¹), which is a proxy for biomass. The samples were collected daily and syringe filtered through GF/C filter paper (Whatman, 1.2 µm pore size). Thereafter, the chlorophyll *a* was estimated by

acetone extraction method¹¹. The TOC content was measured, again, at the end of the experiment using Shimadzu TOC analyzer (Model TOC LCPH). Triplicate set was maintained for all the tests.

The data were analyzed by plotting in MS Office excel sheet. Repeated measure ANOVA was performed to check the statistical significance of the nutrient effect on the biomass growth. Post-hoc Tukey analysis was done whenever there was significance ($P < 0.05$). Spearman rank correlation was performed to analyze the correlation between the experimental solution and the biomass growth. Further analysis of ANCOVA was carried out to find the effect of TOC and its correlation to the growth of biomass. All the statistical analysis were performed employing Statistica software v8. Normality of data was checked before the analysis by Kolmogorov-Smirnov & Lilliefors test.

Results

The repeated measure ANOVA analysis showed that the nutrient concentration had significant effect ($P < 0.001$) on the biomass growth of *S. costatum*. The *S. costatum* growth was most affected by the 40% solution of post decomposed leaf, it was followed by 60% diluted solution of post decomposed petiole. Optimum biomass growth was recorded after the third day of incubation (Figure 1). This was followed by 60% and 10% solution of post decomposed leaf. The solution of root and the mixture of all the three solution, had negligible effect on the biomass growth of the culture. TOC concentration was high in 40% (24 mg.l⁻¹) and 60% (21 mg.l⁻¹) solution of decomposed leaf (Figure 3a). ANCOVA results showed that the TOC of solutions of decomposed leaf, root and its mixture (all the three solutions) had significantly affected ($P < 0.05$) the biomass growth of *S. costatum*. However, TOC in solution of decomposed petiole was not statistically significant ($P > 0.05$) on the biomass growth.

The *T. subtilis* culture showed a gradual increase in the biomass over a period of time. The source of nutrient and its concentration had a significant effect ($P < 0.01$) (Repeated measure ANOVA analysis) on the biomass growth. Maximal biomass growth was recorded on the fifth day of the culture under 10% solution of decomposed root followed by mixed experimental solution of 40% and 60% (Figure 2). Biomass growth declined subsequently. Culture under different solutions of decomposed parts showed

Table 1 — Initial concentrations of total organic carbon (TOC) and nutrient constituents obtained from the decomposition of water hyacinth (*Eichhornia crassipes*)

Plant parts	TOC (mg.kg ⁻¹ wet wt)	Nutrient (mg.kg ⁻¹ wet wt.)				
		NH ₄ ⁺ -N	NO ₂ ⁻ -N	NO ₃ ⁻ -N	PO ₄ ⁻ -P	SiO ₃ ²⁻ -Si
Leaf	1888.4	486	63	135.3	3651	2957.6
Petiole	817.72	445	21.8	52.5	1036	1432
Root	324.78	230	29.3	331.58	1488	594.4

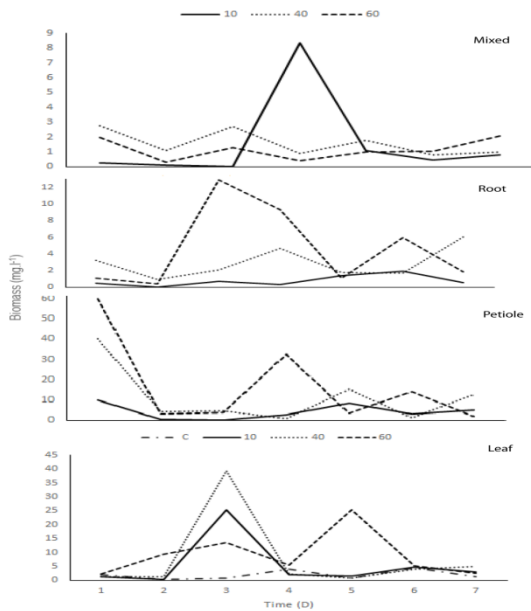


Fig. 1 — Biomass development under different nutrient concentration of different degraded Eichhornia plant matter. Control (C – Filtered seawater (0.22 μ), solution of leaf, petiole, root and mixed of all (1:1:1) *Skeletonema costatum*

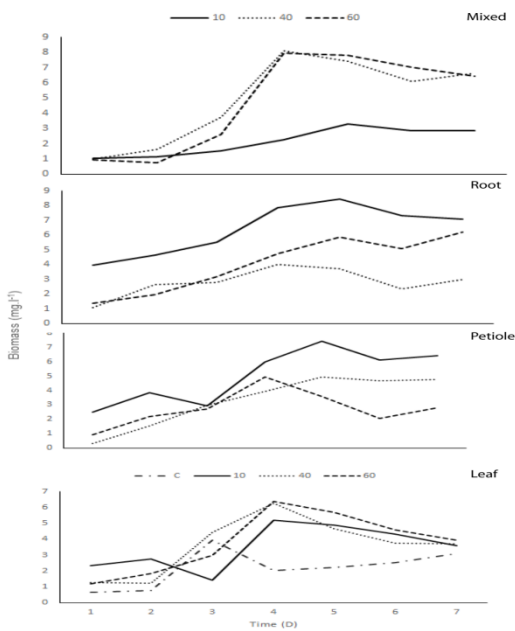


Fig. 2 — Biomass development under different nutrient concentration of different degraded Eichhornia plant matter. Control (C – Filtered seawater through 0.22 μ), solution of leaf, petiole, root and mixed of all (1:1:1) *Thalassiosira subtilis*

similar trend. The highest TOC concentration was ca 14 mg.l⁻¹ in 60% diluted solution of decomposed leaf, followed by petiole (Figure 3b). ANCOVA analysis showed that the TOC concentration in leaf and mixed decomposed solution significantly affected the

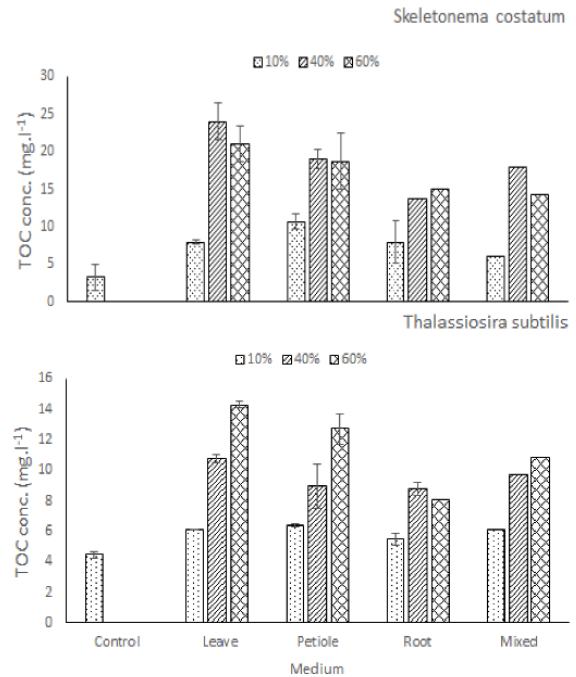


Fig. 3 — Total organic carbon (TOC) concentration in different medium type which was used to test the productivity in different concentration. Control – C (Filtered seawater through 0.22 μ). a. *Skeletonema costatum*, b. *Thalassiosira subtilis*

biomass of the culture ($P < 0.05$). However, no significant effect of TOC in the petiole and root decomposed solution was observed ($P > 0.05$).

Further analysis by Spearman rank correlation showed that the biomass growth in solutions derived from petiole and root decomposition ($P < 0.05$; $r = 0.75$) were significantly correlated in *S. costatum*; whereas leaf and mixed decomposed solutions ($P < 0.05$; $r = 0.95$) were strongly correlated with the biomass growth in *T. subtilis*.

Discussion

The solution obtained from decomposed water hyacinth had a variable effect, and the present study showed that the solution had a significant effect on the biomass growth of the phytoplankton. Potential biomass production is determined by the nutrient status¹². Solution of the leaf promoted the highest growth followed by solution derived from petiole decomposition in the case of *S. costatum*. While in *T. subtilis*, the root decomposed solution favored the highest biomass growth. The use of biomass is a better way to measure the growth rate¹³.

The solution obtained from the decomposition of different parts contained high concentration of nutrient, such as ammonium-N, phosphate-P and

silicate-Si. It was apparent that high ammonium-N, phosphate supported by high silicate concentration promoted high biomass growth in the two species (Table 1). Nitrate-N is the main nutrient source for phytoplankton growth, but it utilizes ammonium when nitrate is limiting in the environment¹⁴. Ammonium-N was found to have been the preferred nitrogen source for both the phytoplankton species in the present study.

The preference of ammonium-N is related to low energy cost in ammonium-N assimilation to nitrate-N assimilation¹⁵. In addition, high ammonium-N concentration showed a positive correlation with the phytoplankton proliferation¹⁶. Further study suggested that the preference for ammonium-N was by specific groups, especially green algae and cyanobacteria. Incorporation of nitrogen led to higher chlorophyll *a*, total biomass, of the phytoplankton¹⁷. High silicate-Si content in the solution of decomposed water hyacinth have significant potential to affect the phytoplankton productivity as it is an important cell wall building material of Bacillariophycean group in an estuarine ecosystem.

The final concentration of TOC was contrastingly different between the two phytoplankton culture media. In the case of *S. costatum*, there was an increase in the concentration of TOC. Increase was probably contributed by the senescing cells, but *S. costatum* is also a known exopolysaccharide producer¹⁸. However, TOC concentration was low in the case of *T. subtilis* culture.

Eutrophication promotes abnormal congregation of phytoplankton species due to close relation between the trophic state of the water column and the species diversity in aquatic communities¹⁹. *S. costatum* populations are readily affected by the phosphate and silicate rather than nitrogen²⁰ (Telesh 2004). This probably must have resulted in the high biomass growth of *S. costatum* culture in the present study. *S. costatum* is nontoxic, but excessive biomass will deplete the dissolve oxygen leading to mortality of organisms^{21,22}. And of the two species, *S. costatum* is known to cause frequent bloom in eutrophic environment^{23,24,25,26}.

It has been reported that the Cochin back water is influenced by anthropogenic activities which includes point source and non-point source discharges. Prominent amongst them are industrial and domestic waste discharges. However, in addition to these and other anthropogenic perturbation, natural process in the form of decomposition of water hyacinth, as

observed in the present laboratory experiments, may also contribute to the degradation of the health of the local ecosystem by way of introducing organic matter and nutrients. Multiple factors contribute to the bloom, but the transient nutrient flux due to the water hyacinth decomposition is expected to exacerbate the condition. In an era where our environment especially the aquatic environment is under severe stress due to various anthropogenic activities, nutrient flux through the decomposition of huge aquatic macrophyte biomass can have a significant effect on the aquatic ecosystem productivity. Considering the nutrient flux from the decomposition of water hyacinth and the blooming nature of *S. costatum*, it is predicted that there is a greater likelihood of *S. costatum* bloom post water hyacinth decomposition.

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