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Designing of effective substrate models from dried branches of plants for periphyton growth in aquatic ecosystem

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ABSTRACT

Periphyton plays an important role in aquatic ecosystems. It is a complex aquatic biota attached to the submerged substratum. It performs various vital functions in aquatic life; one of the important roles of periphyton in aquaculture is food supply. Various substrates were used in research such as biodegradable and non-biodegradable. This research is focused on biodegradable dried tree branches, which can be utilized as the substrate for the periphyton growth. Many investigators studied the isolated branches of trees as substrate for periphyton growth, but in this research, we designed the substrate models from the tree branches to enhance the production of periphyton. In the present study, three plant species were used as a source of substrate such as Bamboo, Babul and Mulberry. The six different models were constructed from the sticks of these three plants. These models were subjected to the assessment of periphyton growth in vitro conditions. The results concluded that the models are beneficial for the growth of periphyton than the isolated form of substrate. The pyramid model of Babul and the raft model of Mulberry show maximum growth of periphyton.

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1. Introduction

Periphyton, also known as biofilm, is a complex microecosystem that naturally can respond to and recover from stress (Sabater et al., 2007). The periphyton community is composed of green algae, diatoms, bacteria, fungi, protozoans, zooplanktons and smaller invertebrates (Azim and Asaeda, 2005); red algae, chrysophyceans and tribophyceans are also found (Graham and Wilcox, 2000). Along with organisms, this biological entity also includes calcium carbonate and detritus. It often grows on submerged objects, such as rocks, plants, and sediments, and it may easily move across substrates (Wu, 2016). A variety of biotic and abiotic factors have an impact on the structure and composition of periphyton communities. Periphyton development is influenced by water type, light availability, transparency, turbidity and physico-chemical parameters (Weitzel, 1979). Periphyton is of growing interest worldwide. It is important for a number of functions, including the fixation of carbon and nutrients, the detection of water pollution, the enhancement of water quality, increase of the food supply in aquatic ecosystems and wastewater treatment also (Azim, 2005). Periphyton plays a crucial role in aquatic systems because it offers the community structure and primary productivity that support a wide range of aquatic animals. Small invertebrates, fish, and shrimp may readily graze on periphyton, which greatly increases the productivity of any aquatic habitat, whether it be natural or artificial (Azim, 2005).

In aquaculture ponds, any material with surface area can support periphyton production. Substrate provides additional shelter, allowing more resources to flow into fish biomass. The substrates attract the fishes to provide shelter for protection from predators. It also provides suitable breeding habitat and availability of natural food. Furthermore, cultured fishes can graze upon attached periphyton more effectively than small planktonic algae harvested from the water column by filter feeding (Azim, 2005). Designing the substrate model is a simple idea to enhance the periphyton growth. The idea behind that more surface area gives more production of periphyton; these models increase surface area for periphyton growth and serve as food source in the aquatic ecosystem. In this research, the models used are small in size and made for laboratory purposes, we can install copies of these in the form of large sized model in aquatic ecosystem for the effective and large-scale growth of periphyton. It looks like cage through which fishes can move freely. It provides shelter and breeding habitat for fishes. Also, these models occupy small area as compared to isolated substrates in culture system, which ultimately decreases the stocking density of substrate models in ponds, this saves space in the culture system. In this research, the substrate models were constructed from the sticks of the three different trees such as bamboo sticks (*Bambusa vulgaris*), babul sticks (*Acacia nilotica*) and mulberry sticks (*Morus alba*). The study aims to assess the growth of periphyton biomass on different substrate models in terms of dry weight.

2. Materials and Methods

2.1. Collection of Periphytic Water Sample:

The periphytic water sample was collected from the canal of Kayadhu River system, Kalamnoori, Dist. Hingoli, Maharashtra, India in the month of March, 2023.

2.2. Physico-chemical Parameters of Water:

The examination of physico-chemical parameters of river water and periphyton grown water from the set up were tested, such as, temperature, pH, dissolved oxygen, chloride, phenolphthalein alkalinity and total alkalinity, free CO_2, hardness and calcium hardness by following standard procedure of water examination. (Trivedy et al. 1998 and Eaton, APHA 1995)

2.3. Construction of substrate models:

The substrate models were constructed from the three plant sticks for the study, such as bamboo tree, babul tree, and mulberry tree.

2.3.1 Pentagonal roof hut model:

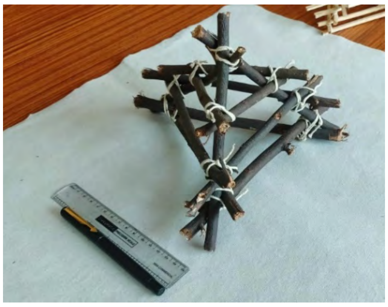
This model is made by using bamboo sticks arranged in a pentagonal shape one above the another in such a way that it forms a ladder like structure from each side. The bamboo sticks are tied by a cotton thread to fix the shape and at the top one common knot is made to support the model for easy handling.

2.3.2 Pyramid model:

This model is made by using bamboo sticks arranged in a pyramid-like structure in which, from each side, the bamboo sticks are placed one above the other to make a ladder like structure. The bamboo sticks are fixed by the cotton thread, and the common knot was made for support and handling at the top.

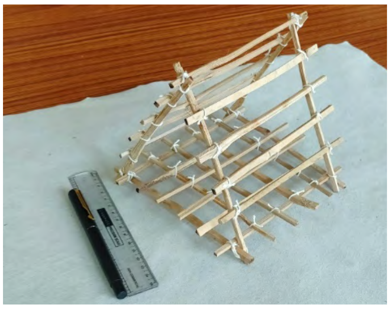
2.3.3 Modified trigonal pyramid model:

This is the modified model of trigonal pyramid, made up of babul sticks. In this model the three sticks are arranged vertically in such a way that it makes triangle shape at the base and gives three triangular sides. On each side the sticks are arranged in horizontally one above the other, giving some space in between. The sticks are fixed by cotton thread.



2.3.4 Prism model:

This model is made by bamboo sticks. The model consists of three rectangular sides and two triangular sides; therefore, it is named as prism model. The two rectangular sides have horizontally arranged sticks fixed to the two vertical sticks, and the one rectangular side at the bottom has intersecting sticks that make small squares. The triangular sides are open. The whole structure is fixed by the cotton thread.



2.3.5 Cubic model:

This model is made up of mulberry sticks. The mulberry sticks were arranged in the shape of cube. Three horizontal sticks were arranged and another three sticks were placed perpendicular to it. Likewise, arrange all these sticks alternately to form a cube shape. All the sticks fixed by the cotton thread and made a common knot at the top for handling.

2.3.6 Raft model:

This is the simplest model made by arranging mulberry sticks side by side. All the sticks were secured by the cotton thread and knotted at one side for handling. This model can be placed on any irregular or regular surface like stone, rock etc.

2.4. Experimental Set Up for Growth of Periphyton:

The experiments were done in laboratory under controlled conditions. The experimental set up consists of a small plastic trough of a volume 15 liters having 1 cm soil layer at the bottom. The soil is provided with fertilizers such as cow dung (8 g), NPK (1.6 g) and Urea (1.6 g). The basic periphytic culture water was collected from the river and fresh water in 1: 9 ratios added in a trough. The stone weights were attached to the constructed substrate models for the submersion in the water. The oxygen is provided by aquarium air pumps and light is provided by tungsten bulb for photosynthetic activity. The experimental substrate models were kept in the trough for 30 days (Shaikh & Chavan 2015).

2.5. Taxonomic identification of periphyton:

For the taxonomic identification the substrate models were removed from the water of the periphyton culture system. With the help of soft brush, the periphyton collected from the substrate models and preserved in 4% formalin. Temporary mounts of periphyton were prepared in glycerin and xylene. The samples were identified using identification keys from Fresh Water Biology, edited by Edmonson (1959).

2.6. Biomass Estimation of Periphyton:

The biomass of periphyton was estimated in terms of dry weight. The periphytic sample was collected from the substrate models by scrapping area of about 1 cm^2. The sample was collected in the Whatman filter paper. Dry these samples in incubator at 37 °C for 24 hrs. The weight of filter paper was measured before and after the collection of periphyton. The total dry weight of the periphyton obtained by deducting the weight of filter paper from the dried filter paper with periphyton sample.

3. Results and Discussion

3.1 Physico-chemical analysis of water:

The physico-chemical analysis of initial water and periphyton grown on substrate models culture system are shown in table 1. The physicochemical parameters of water were within the limits suitable for periphyton growth. Variations of some parameters in vitro condition occur due the change in habitat. The air pumps increase the DO of water, and other factors such as CO_2, chloride content, total alkalinity, phenolphthalein alkalinity and Ca^{++} hardness fluctuate due to the addition of fertilizers and other factors. But all the conditions are suitable for the periphyton growth.

3.2 Taxonomic identification of periphyton:

The sample of periphyton grown on different substrate models consist of different genera of class Chlorophyceae such as *Hormidium, Rhizoclonium, Spirogyra, Clostrium*, *Radiofilum* and some algal filaments and it also shows different genera of Bacillariophyceae such as *Bacillaria, Cymbella* and *Pinnularia*.

3.3 Estimation of biomass:

The biomass estimation of periphyton on different substrate models was done after the 30 days time period. The periphyton growth on substrate models was measured in terms of dry weight (g/cm^2). The growth obtained on the bamboo pentagonal roof hut model is 0.02 (g/cm^2), the

Table 1. Physico-chemical parameters of initial water and substrate model added water

Sr. No.	Parameters	River water	Pentagonal roof hut model	Pyramid model	Modified trigonal pyramid model	Prism model	Cubic model	Raft model	Standard range
1	Temperature ˚C	28	28	28	28	28	28	28	25-32
2	pH	8	8.4	8	8.6	8.2	8.4	8	7-9
3	DO (mg/l)	8.51	14.83	15.40	14.83	13.05	15.40	14.7	5-15
4	Free CO2 (mg/l)	9.6	10.6	10.7	10.8	10.9	9.9	10.6	1-10
5	Chloride (mg/l)	46.9	65.18	54.94	84.3	54.94	88.32	72.86	1-100
6	PA (mg/l)	40	100	80	120	80	100	100	50-300
7	TA (mg/l)	140	140	150	210	150	140	120	50-300
8	Ca^{++} hardness (mg/l)	61.72	92.18	85.77	76.87	85.77	82.56	61.72	5-100

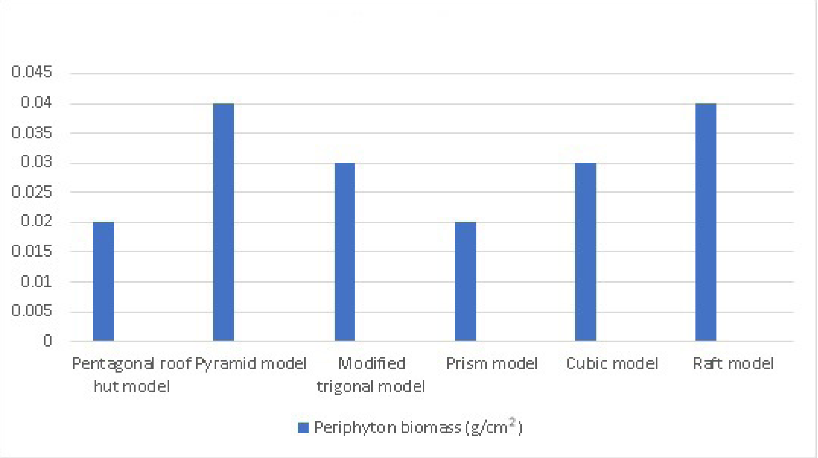


Fig. 1. Periphyton biomass

babul pyramid model is 0.04 (g/cm^2), the babul modified trigonal model is 0.03 (g/cm^2), bamboo prism model is 0.02 (g/cm^2), mulberry cubic model is 0.03 (g/cm^2) and mulberry raft model is 0.04 (g/cm^2).

From the result, it is observed that the similar material used for the construction of the model has less or no difference in the production of the periphyton. This is the first-time use of biodegradable substrate models from locally available plant species used for periphyton growth. Various research on biodegradable substrates (in isolated form) has been done and showed increased growth of periphyton (Azim et al., 2002; Chavan et al., 2012; Gangadhara & Keshavanath, 2008; Keshavanath et al., 2012; Rai et al., 2018; Shaikh et al., 2019). All these substrate models are beneficial for the growth of periphyton. Based on this research babul pyramid model and mulberry raft model have high growth of periphyton in vitro condition.

4. Conclusion

The mentioned substrate models can be utilized in periphyton-based aquaculture systems. Scientifically it can be said that these substrate models are efficient for the periphyton growth. The other advantage of these models is it increases the surface area for the maximum production of periphyton. Growth of periphyton affected by different factors but one of most important factors is nature of substrate. From the results, we conclude that all the models are useful for periphyton growth. They are effective because they increase periphyton production in culture system rather than the isolated form of substrate. Based on the model efficiency, from the result, it can concluded that the babul pyramid model and mulberry raft model are more effective for periphyton growth than other models.

In future, the researchers can design more substrate models inspired by this research. The comparison of growth patterns on different substrate models could be done. Which model is more effective and which tree wood gives more periphyton production could be identified. Researchers could also determine the durability of models and how much stocking density of substrate model required in culture system.

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