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Maturation of different filter media using culture water

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Abstract
For the development of freshwater prawn farming, it is advantageous to have a freshwater prawn hatchery near inland area. With the help of artificial sea water (ASW) and filtration system operation cost can further be reduce to make it economically viable. In the present study, performance of different filter media ie. coir + bamboo (T_1); perforated PVC pipe rings (T_2); synthetic media (T_3) was tested in artificial seawater recirculation system by analyzing water quality parameters of *Macrobrachium rosenbergii* larval rearing tanks. At the end of the experimental trials, it is concluded that artificial seawater with Bamboo rings and coir (T_1) can be effectively used for production of Postlarvae of *M. rosenbergii* in distantly located inland areas.

Keywords: Filter media, Artificial sea water (ASW), recirculation system

Introduction
The aquaculture of *M. rosenbergii* is on rise, the seed availability remains to be one of the major hurdles in its culture progress. For operation of any successful aquaculture project, the basic requirement is sufficient availability of quality seed throughout the year. Due to seasonal changes, pollution, overfishing of brood stock and seasonal variations, the availability of natural seed is restricted (Reddy *et al*., 1991) [41]. Heterogeneous growth and mixing of other than giant prawn species also contributes to the impediment of its culture. Thus, hatchery produced seed and its timely availability are the only solutions to overcome these problems.
In nature, the prawn migrates to estuarine areas for breeding purpose. The brackish water is necessary for completion of its life cycle. This particular characteristic has been transferred into a pioneering work by (Ling, 1969) [28] for completion of his history under laboratory conditions. The technology was then adopted for mass-scale production of post larvae (Fujimura and Okamoto, 1972) [12]. Subsequently, numbers of hatcheries have been established in different parts of the world along the sea coasts. Seed produced in these coastal hatcheries is supplied to nearby coastal farms and relatively closely located inland areas. Distantly located vast inland areas cannot be brought under culture mainly due to the constraints like long distance transportation adding to extra seed cost and higher mortalities. The use of artificial seawater instead of natural seawater has proved to be an alternative source for the production of post larvae (Reddy *et al*., 1991; Qureshi *et al*., 1994; Kanaujia *et al*., 1996; Mallasen and Valenti, 1998; Belsare *et al*., 2007; Jogale, 2010) [41, 40, 20, 30, 6, 18]. Therefore, the use of artificial seawater can be a boon to set up hatcheries in inland areas.
Preparation of artificial seawater requires combination of various chemicals which increases operational cost of hatchery, reflecting in increased cost of seed. Therefore, effective measures have to be employed to reduce the water requirement of hatchery. The water requirement of hatchery can only be reduced by treatment of discharged water in a proper way, so that it can be reused in hatchery. For establishment of recirculation system for hatchery, proper quality and quantity of filters are needed to be employed to maintain the quality of water (Gross *et al*., 2003) [14].
Recirculation hatchery systems with appropriate filtration facilities have been used to maintain low ammonia and nitrite levels by means of nitrification (Valenti and Daniels, 2000) [54]. Such systems have several advantages over a flow through or static systems. These systems regulate environmental parameters by improving water quality to produce quality seed, reduce disease outbreaks, minimize labour cost, reduce water losses and abide to the non-violation of environmental regulations on effluent discharge (Sandifer and Smith, 1978; Uar, 1983; Avnimelech, 2006; Lyssenko and Wheaton, 2006; Lekang, 2007; Kumar *et al*., 2009;

Pedersen, 2012) [46, 52, 5, 29, 24, 23].

Primarily ammonia (NH_3) is excreted as nitrogenous waste by fish and other aquatic organisms. Uneaten feed, fish excreta and fish metabolic waste also help to increase the ammonia level in the system (Chin and Chen, 1987; Correia *et al*., 2000; New, 2002; Lekang, 2007) [9, 11, 36, 24]. Excess ammonia levels in the system adversely affect the culture system (Wickins 1976; Armstrong *et al*., 1978) [55, 3] and therefore to maintain ammonia levels biological filters used in recirculation system where ammonia convert to nitrate (NO_3^-) through nitrification (Spotte, 1979) [49], which is less harmful to the fishes. The circulatory aquaculture system allows high stocking density by maintaining water quality and removing metabolite waste from the culture system (Hirayama, 1974) [16] through different filter media (Kruner and Rosenthal, 1983) [22].

Considering the importance of the filter medium and to devise the cost effective and functionally efficient filtration system, the present study is carried out with the following objectives: To evaluate the efficiency of different filter media in artificial seawater recirculation system for larval rearing of *M. rosenbergii*.

Materials and Methods

Preparation of filter beds using different filter media

Commercially available canister filters were used as a filtration device during the experiment (Plate 1). It was rectangular in shape having dimensions of 20 × 20 × 30 cm. Each filter device was divided into three chambers horizontally as the horizontal partitions of filter provide more efficient performance (Choudhary *et al*., 1993) [10]. The chambers were made up of plastic and were perforated at the bottom in order to pass the water through all three compartments.

Canister filters were used for filtration of water discharged from culture tanks. The three different filter chambers were filled with three different types of filter media. To evaluate the efficiency of different filter beds, six different filter media were selected to design the combined filtration unit of canister filter.

Two major factors were considered *viz*., sufficient porosity and diameter along with higher surface to volume ratio for selection of filter media (Valenti and Daniels, 2000) [53]. In the first filtration chamber of each filter, three different media, bamboo ring covered by coir, perforated PVC pipe ring and commercial media (manufactured by BOYU) were used. The second chamber of all filters was filled with activated charcoal to absorb obnoxious gases like Hydrogen sulphide (H_2S) while, polywool (Plate 2, A) was used in the third chamber of all the three filters. As the non-calcarious substrates do not buffer pH efficiently (Bower *et al*., 1981) [7]. Therefore, oyster shells (Plate 2, H) were used along with polywool in all the treatments. Thus, three filters in combination with different filter media were prepared and used in three different treatments *viz*., T_1, T_2, and T_3 (Plate 3).

1. Bamboo ring + coir

Circular rings were prepared from dried bamboo having average thickness of 6.26 ± 0.08 mm and average diameter of 21.63 ± 0.08 mm (Plate 2, C). The external surface of each bamboo ring was covered by coir (average length 8.52 ± 0.31 cm and average diameter 0.27 ± 0.04 mm) (Plate 2,B) in order to increase surface area for formation of microbial growth and to increase efficiency of material (Plate 2,D).

2. Perforated PVC pipe ring

PVC pipe having diameter of 20 mm were perforated by using drill machine (Plate 2, E). Each perforation has diameter of 3.05 ± 0.05 mm while, space between two perforations was 8.62 ± 0.56 mm. Such PVC pipe was cut into circular rings (average thickness 11.00 ± 0.19 mm).

3. Commercial media

Commercial media (manufactured by BOYU) used in a filters, available in the form of circular hollow rings (average diameter of 12.12 ± 0.11 mm and average thickness was 12.22 ± 0.07 mm) for settlement of microbes (Plate 2, F).

4. Activated charcoal

Pieces of activated charcoal (average length 2.65 ± 1.37 cm, average diameter of 3.79 ± 0.05 mm) were used in second chamber of each filtration device (Plate 2, G).

Evaluation of suitability of filter media

The evaluation of filter media was done using discharged water of the Aquaponics unit of the college. The discharged water was collected in 150 L FRP tanks. Water quality parameters such as ammonia (NH_3-N), nitrite (NO_2-N), nitrate (NO_3-N), pH and temperature were recorded initially and then water was passed through canister filters till the water quality suitable for culture was restored. Water parameters were daily recorded to evaluate water quality. During filtration, water flow rate was maintained at 1 L min^{-1}.

Experimental procedure

For evaluating the suitability of filter media, the discharged culture water was stored in four different FRP tanks. Out of which, three tanks were connected to canister filters as per the following experimental treatments.

T_0: Control (No filtration)

T_1: Filter A (Polywool + Activated charcoal + Bamboo rings with coir)

T_2: Filter B (Polywool + Activated charcoal + PVC pipe roles)

T_3: Filter C (Polywool + Activated charcoal + Commercial media)

T_4: Filter D (Without any media)

The water quality parameters such as ammonia (NH_3-N), nitrite (NO_2-N), nitrate (NO_3-N), pH and temperature were recorded daily during morning hours. The recirculation of water was carried out till desired water quality was achieved.

Three trials were conducted to evaluate the efficiency of different filter media for duration of 10 days.

Results and Discussion

Five treatments *viz*., T_0, T_1, T_2, T_3 and T_4 were used to evaluate the effect of filter media on concentration of ammonia (NH_3-N), nitrite (NO_2 - N), nitrate (NO_3 - N), pH, and temperature in discharged water (Table 1).

Artificial seawater (ASW) has been successfully used in closed system hatcheries. In comparison with the natural sea water, the use of artificial seawater considerably reduces various types of risks; such as pollution, parasites, and the presence of competitors and predators in larval rearing tanks. Thus, the water quality of larval rearing systems is enhanced using artificial seawater. Such systems of using artificial seawater have been successfully used for the completion of larval cycle and for the seed production of *M. rosenbergii*

(Reddy *et al*., 1991; Qureshi *et al*., 1994; Kanaujia *et al*., 1996; Mallasen and Valenti, 1998; Belasare *et al*., 2007; Jogale, 2010) [41, 40, 20, 30, 6, 18].

Recirculatory aquaculture system uses less water by filtering the water from the system and facilitates high production from less land (Liao and Mayo, 1972; Wing and Malone, 2006; Leungprasert and Chanakul, 2010) [27, 31, 26].

The recirculation system effectively and economically uses various chemical salts in ASW. In the system, different salts were used in altered compositions for formulation of artificial seawater by different authors who mainly include Common salt (NaCl), Potassium chloride (KCl), Calcium chloride ($CaCl_2.2H_2O$), Magnesium chloride ($MgCl_2.6H_2O$), Sodium bicarbonate ($NaHCO_3$), Potassium bromide (KBr), and Ethylene Diamine Tetra Acetic acid (EDTA). Numbers of salts vary from 7 to 21. Thus considering the economy involved in preparation of ASW, the method followed by Jogale (2010) [18] was adopted in the present study. Jogale (2010) [18] has used seven salts for the preparation of ASW.

Numerous research workers used several types of filter media *viz*., pile cloth, plastic plate, gravels and corrugated sky light roof plate (Kim *et al*., 1987) [21]; crushed leca and kaldnes rings (Lekang and Kleppe, 2000) [25]; plastic cheaps and polythene blocks (Ridha and Cruz, 2001) [42]; plastic rolls, PVC pipes and scrub pads (Al-hafedh, 2003) [1]; artificial plastic (Rusten *et al*., 2006) [43]; polystyrene micro beads (Malone and Pfeiffer, 2006; Timmons *et al*., 2006) [31]; wood chips and wheat straw (Saliling *et al*., 2007) [44]; zeolite, ceramic particles and carbonate (Qui *et al*., 2010) [39]; lava stones and oyster shells (Ogunlela and Ogunlana, 2011) [37]; glasswool, granite rock and charcoal (Moreira *et al*., 2011) [34]; sand (Summerfelt, 2006; Harwanto *et al*., 2011) [50, 15] and coir (Sherman, 2006; Manoj and Vasudevan, 2012) [47, 32]. In the recirculation system of *M. rosenbergii* larval rearing, different filter media like sand or gravels (Menasveta, 1982; Singholka and Sukapunt, 1982; Uar, 1983; Reddy *et al*., 1991; Nair and Hameed, 1992) [33, 48, 52, 41, 35], calcareous media or oyster shells (Menasveta, 1982; Mallasen and Valenti, 1998; Islam *et al*., 2000) [33, 30, 17], packed bed bioreactors (PBBR) (Kumar *et al*., 2009) [23] and ozone (Menasveta, 1982) [33] have been found to be useful.

In the present study, while selecting the filter media, cost and availability factors were also considered along with its suitability. Locally available materials such as coir and bamboo pieces in the form of rings were used in T_1. Perforated PVC pipe rings and commercial media in T_2 and T_3 respectively. Whereas, polywool, activated charcoal and oyster shells were common in all the treatments. Prior using for larval rearing, a short term experiment was conducted to test efficiency of these filter media for maintaining water quality. By the results of experiment, all the selected filter media was efficient in elimination of ammonia and ammoniacal products. Comparing the results of all the treatments, water quality was well maintained by using coir and bamboo rings which reflected in better removal of ammonia and production of nitrate. Even statistically, T_1 was significantly better than T_2 and T_3.

During adoption of recirculation system, appropriate filter media and flow rate of water recirculation play a major role in system efficiency. Bio-filter in re-circulatory system plays a vital role in nitrification of ammonia (Brune and Gunther, 1981) [8]. Higher the water flow rates through the filter higher the nitrification process (Kaiser and Wheaton, 1983) [19]. Bio-filter size can be reduce by increasing the flow rate which varies from 140 to 500% daily (Valenti *et al*., 2010; Sandifer and Smith, 1975; Singholka and Sukapunt, 1982; Uar 1983; Chowdhury *et al*., 1993; Aquacop, 1983; Griessinger *et al*. 1989) [54, 45, 48, 52, 10, 4, 13]. In the present study, the water circulation rate through the bio-filter was 1500 % which was found to be suitable to boost the nitrification process in the designed bio-filters. The findings of the present study are in complete agreement with Kaiser and Wheaton, (1983) [19], Aquacop (1983) [4], Griessinger *et al.* (1989) [13] and Valenti *et al.* (2010) [54].

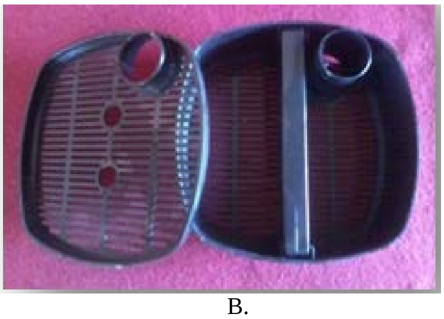
The factors discussed above suggest that artificial seawater can be effectively replaced for natural seawater. The requirement of salinity to be maintained for completion of larval rearing of *Macrobrachium rosenbergii* can be fulfilled by the use of ASW. Additionally, the recirculation system helps to rotate the used water again and again in view of relatively higher cost involved in preparation of artificial seawater. The use of filtration media such as bamboo rings and coir can be used to enhance the efficiency of recirculation system. The bamboo rings and coir have also shown very efficient in removing ammonia and ammoniacal products.

Table 1: The values of ammonia (mgL^{-1}) in all the treatments.

	T_0	T_1	T_2	T_3	T_4
Ammonia	0.7697±0.18	0.1589±0.11	0.1666±0.20	0.1811±0.15	0.5932±0.20
Nitrite	3.3213±0.40	0.9425±0.33	0.9997±0.26	1.0635±0.35	2.8293±0.34
Nitrate	0.0166±0.03	0.5064±0.25	0.4543±0.37	0.4164±0.36	0.0205±0.22
pH	9.603±0.18	8.078±0.29	8.102±0.30	8.114±0.23	8.736±0.18
Temperature	29.386±0.20	27.573±0.24	27.973±0.23	27.639±0.34	28.129±0.29

(Methods followed by AOAC, 2005)

A.



B.

Plate 1: A. Canister filter, B. Filter chamber

Plate 2: A. Polywool, B. Coir, C. Bamboo rings, D. Bamboo ring + coir, E. Perforated PVC pipe rings, F. Commercial media, G. Activated charcoal, H. Oyster shells

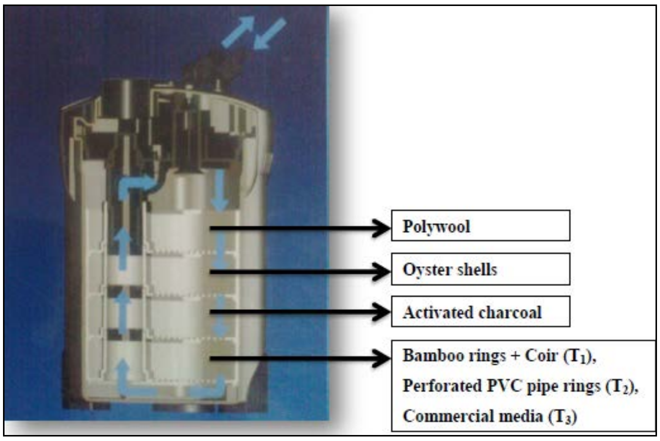


Plate 3: Filter Media combinations in canister filter

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