Water quality management in shrimp culture

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ABSTRACT

Studies were carried out on the physico-chemical parameters of pond water used for shrimp culture. The physical parameters studied were air and water temperature, water depth and transparency, total solids (TS), total dissolved solids (TDS) and total suspended solids (TSS). Chemical parameters studied were pH, salinity, total alkalinity and dissolved inorganic phosphates. These were recorded from the day of culture till the harvest period at 30 days interval. Air and water temperature were increased from the day of culture till the harvest period. Transparency of the water used for the culture was high (40±0.1cm) during initial days and reduced thereafter. Water depth was increased from the day of culture till the harvest period. Suspended and total solids recorded were high on day 90 and total dissolved solids were high (20±1.2 mg/l) on the day of culture and harvest. The level of pH recorded was high (8.3±0.0) on day 60 and the level of salinity and total alkalinity recorded was high on day 30. The dissolved inorganic phosphate level was high (1.0±0.0 mg/l) on the day of culture which became reduced during the growth and harvest period of shrimp. The feed consumption and gain of body weight were also recorded on each 10 days interval. The body weight was increased as the day of culture was increased and it was positively correlated with the quantity of the feed consumed.

Keywords: shrimp, pH, salinity, phosphate, salinity, alkalinity

INTRODUCTION

Shrimp culture is the process of growing baby shrimps up to a marketable size in an enclosed water body for a specific period of time. It is an aquaculture business that exists in a marine or freshwater environment, producing shrimp or prawns [1]. The total global production of farmed shrimp reached more than 1.6 million tonnes in 2003, representing a value of nearly 9 billion U.S. dollars. About 75% of farmed shrimp is produced in Asia in particular in China and Thailand. The other 25% is produced mainly in Latin America, where Brazil, Ecuador and Mexico are the largest producers. The largest exporting nation is Thailand. Aquaculture of shrimp is an alternative method to overcome the exploitation of shrimp population due to overfishing and overseas demand. Shrimps are aquatic organisms inhabiting the seas, estuaries and brackish waters.

All farmed shrimp are of the family Penaeidae, and just two species namely *Litopenaeus vannamei* (Pacific white shrimp) and *Penaeus monodon* (giant tiger prawn) account for roughly 80% of all farmed shrimp.There are more than 50 varieties of shrimps and seven of them are identified for aquaculture. They are *Litopenaeus vannamei, Penaeus monodon*, *P. merguiensis*, *P. chinensis*, *P. stylirostris*, *P. vennamei*, and P. *japonicas. Litopenaeus vannamei* is one of the most important commercial species in the shrimp farming industry, accounting for approximately 2,328,000 tons of production and 9,218,000,000 dollars of profit [2,3]. In recent years, deteriorating water quality has caused massive financial losses to farmers and has become one of the major

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factors that bottleneck the output and production process [4-6]. Moreover, legal regulations concerning the discharge of effluents from culture farms have become increasingly strict; therefore, establishing a method for scientifically evaluating water quality is an important task for culture risk assessment.

MATERIALS AND METHODS

The shrimp farm selected belongs to M/S Monodona Bioresources Pvt. Ltd., Kundapur, Udupi district, Karnataka. Water samples were collected from the culture pond and brought to the laboratory for analysis. Sampling was carried out at monthly intervals from the day of culture till the harvest. Temperature (air and water) was recorded at the sampling station using a standard mercury thermometer. Transparency of the water was measured using a Sacchi disc. Water depth was measured using a measuring stick. Salinity, total alkalinity, pH, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS) and dissolved inorganic phosphates were analyzed according to the procedures of APHA [7].

RESULTS AND DISCUSSION

Water quality management is basically the management of water quality parameters daily to keep it in optimal conditions for growth of shrimp. In shrimp farming, management of water quality is of primary consideration and degradation of water quality is detrimental to shrimp growth and survival. Water quality management is very important to prevent the environmental stress on shrimp that can accelerate them to various diseases. Water quality parameters that must be managed well in shrimp culture pond are transparency and water color, pH, DO, salinity, temperature, TAN (total ammonia nitrogen), free ammonia (NH_3), and alkalinity. The water quality parameters studied in the present study are pH, air and water temperature, water transparency and depth, TS, TSS and TDS, dissolved inorganic phosphates, total alkalinity and salinity.

pH

The pH of the pond water is indicative of its fertility or potential productivity. Water with pH ranging from 7.5 to 9.0 is generally regarded as suitable for shrimp production. The growth of shrimps is retarded if pH falls below 5.0. Water with low pH can be corrected by adding lime to neutralize the acidity. Water of excessive alkalinity (pH values > 9.5) may also be harmful to shrimp growth and survival. In ponds which are excessively rich in phytoplankton, the pH of pond water usually exceeds 9.5 during late afternoon. However, at daybreak, the pH is usually lower. Excessive plankton growth can be corrected by water exchange. The level of pH recorded in the present study was ranged from 7.3±0.08 to 8.3±0.0 [Figure 1(d)]. Boyd and Pillai [8] reported the importance of pH on the ovarian development of *Penaeus* prawn. pH below 6 may cause impairment of gonad development, spawning, egg production and hatching. High pH (>9.0) is detrimental to the health of prawns.

Temperature

Water temperature plays a very important role in regulating the activities of the cultured animal. The rate of chemical and biological reactions is said to be double for every 10°C increase in temperature. This means that aquatic organisms will use twice as much dissolved oxygen at 30°C than 20°C. It follows therefore that dissolved oxygen requirement of aquatic species is higher in warmer than in cooler water. Many Penaeid species are tropical or subtropical species. The optimum temperature is about 25–30°C and hence many of the species such as *P. indicus*, *P. monodon* and *P. merguiensis* can be cultured throughout the year while *P. japonicus* and *P. orientalis* are limited to the summer growing seasons only. Conversely, if the water temperature is very low metabolic processes in the body of the shrimp is inhibited, so the shrimp do not want to eat. In the present study, air and water temperature were increased from the day of culture till the harvest period. The air temperature recorded was ranged from 29±0.0°C to 32.5±0.0°C and the water temperature recorded was ranged from 24.2±0.0°C to 30.1±0.0°C [Figure 1(a)]. Imai [9] reported that a high temperature weakens the physiological conditions of *Penaeus* and sometimes leads to mortality.

Water transparency and depth

These water quality parameters reflecting the type and density of plankton. The more intense the colour of water, the denser the number of existing plankton. High plankton density may affect the level of dissolved oxygen and pH in the pond. On a sunny day, the amount of dissolved oxygen will be very high and the pH tends to lower, while in the evening there will be very high pH and dissolved oxygen will decrease to less than 2 ppm. Transparency must be maintained at a level of 30-40 cm. If the density of plankton is very high, it must be reduced by adding more water. Transparency of the water used for the present culture was 40±0.1 cm during initial days and reduced thereafter [Figure 1(b)].

TS, TSS and TDS

The amount of total dissolved solids in water may be taken as a measure of organic load. In shrimp culture, waste from the artificial food pellets, shrimp excrement, fertilizers and mineral conditioners used to boost the growth of the phytoplankton are some of the reasons to increase solids in pond water. Indirectly they may also decrease the water depth and transparency. Suspended and total solids recorded in the present study were high on day 90 and total dissolved solids were high (20±1.2mg/l) on the day of culture and harvest [Figure 1(c)].

Dissolved inorganic phosphates

Of the dissolved nutrients, phosphorous plays an important role in aquatic productivity. High values of inorganic phosphates in water showed increasing trend in primary production. There is a close correlation between the cycles of phosphorous and organic production in the coastal backwater. Shrimp production is enhanced by applying phosphate fertilizers to stimulate phytoplankton which is the base of food web. The dissolved inorganic phosphate level was high (1.0±0.0mg/l) on the day of culture which became reduced during the growth and harvest period of shrimp [Figure 1(d)].

Total alkalinity

Alkalinity is the amount of carbonate, bicarbonate, and hydroxide contained in the water. Alkalinity becomes an important key in the water because of its ability to sustain the pH level and low alkalinity in water is poorly buffered against pH change [8]. Standard value in the total alkalinity of pond waters is equal to or greater than 80 ppm and it was found that calcareous water with medium alkalinity are very fertile. If the alkalinity of pond water has a value below the standard, it can be corrected by the application of lime. The level of total alkalinity recorded was high on day 30 and it was ranged from 50±1.2 ppm to 141±2.2 ppm [Figure 1(d)].

Table 1. Feed consumption (gms) and gain in body weight (gms).

Days	Feed consumption (gms)				Gain in body weight (gms)
	6 a.m.	12 noon	6 p.m.	11 p.m.	
0	-	-	-	-	-
10	1000	-	1000	-	-
20	1900	1400	2000	-	-
30	2800	2300	2800	-	-
40	3500	2600	3000	3000	5.60
50	4750	3500	4750	4750	9.48
60	5500	3500	5500	6000	12.50
70	6500	4000	7000	7000	15.70
80	7000	4500	8500	7500	21.98
90	6000	8500	10000	10000	27.00

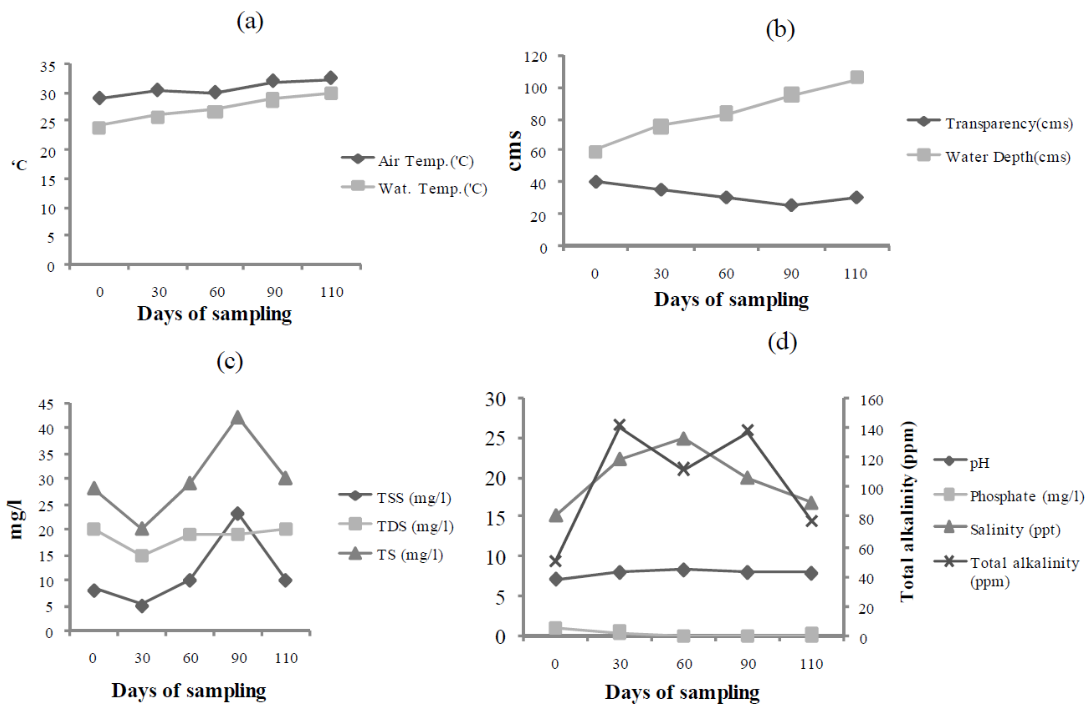

Figure 1. (a) Variations in air and water temperature in culture pond; (b) Variations in transparency and water depth in culture pond; (c) Variations in TSS, TDS and TS in pond water; and (d) Variations in phosphate, salinity, alkalinity and pH in pond water.

Salinity

Optimal salinity is required for shrimp to establish the metabolic processes properly. If the salinity in the shrimp body fluids is higher than the environment, the water in the environment will enter into the shrimp body so that the cell will swell. On the contrary, if the environmental salinity is higher than the salinity of shrimp body fluids, the water in the shrimp body will come out so that the shrimp become thin. Optimal salinity for growth of shrimp is 15-30 ppt. Younger shrimps appear to tolerate a wider fluctuation of salinity than the adults. Due to high evaporation, salt concentration in ponds gradually increases to beyond 40 ppt during the summer months, thus it retards the growth of shrimp. In such cases, the water should be changed frequently either by pumps or through tidal exchange. The level of salinity recorded was ranged from15.2±0.24 ppt to 25±0.0 ppt and it was recorded high on day 30 [Figure 1(d)]. According to Rejistenbil [10] and Sillas and Pillai [11] salinity is a major factor in phytoplankton and zooplankton ecology of brackish and saline water and both planktons form additional important native food for brackish water prawns.

Feeding

Feed plays a major role in shrimp farming and it constitutes as much as 50% of the cost of production. Extensive farms mainly depend on natural food mainly phytoplankton and intensive cultures rely on artificial shrimp feeds as supplement to the organisms that naturally occur in a pond. Artificial feeds are prepared by adding essential additives like single cell proteins, growth promoting substances like steroid hormones and some synthetic substances like antibiotics and drugs to get healthy and faster growth of shrimps. They are fed two to five times daily and feeding can be done manually either from ashore or from boats or using mechanized feeders distributed all over a pond. The feed conversion rate (FCR), i.e. the amount of food needed to produce a unit (e.g. one kilogram) of shrimp, is claimed by the industry to be around 1.2–2.0 in modern farms. For a farm to be profitable, a feed conversion rate below 2.5 is necessary. In older farms or under suboptimal pond conditions, the ratio may easily rise to 4:1 [12]. Lower FCRs result in a higher profit for the farm. The feed consumption and gain of body weight were also recorded on each 10 days interval. The body weight was increased naturally as the day of culture was increased and it was positively correlated with the quantity of the feed consumed (Table 1).

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