Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 4
Open Access

Assessment of Water Quality Parameters during Litopenaeus vannamei cultivation

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Cite this paper as: Naga Murali Chalamalasetti,Sreeya G. Nair, Vinoliya Josephine Mary (2024) Assessment of Water Quality Parameters during Litopenaeus vannamei cultivation. Frontiers in Health Informatics, 13 (4), 1769-1778

Abstract

Aquaculture is the farming of aquatic organisms, encompassing fish, shellfish, and aquatic plants, in controlled or semi-natural environments, a practice that plays a significant role in global food production and ecosystem restoration. Aquaculture involves cultivating freshwater, brackish water, and saltwater populations under controlled or semi-natural conditions and can be contrasted with commercial fishing, which is the harvesting of wild fish. In the present study, water quality parameters such as pH, dissolved oxygen, alkalinity, nitrites, ammonia and total hardness were checked in Litopenaeus vannamei shrimp cultivation pond and reported. The study found consistent pH levels but notable variations in alkalinity and nitrite concentrations, indicating that optimal water quality is crucial for shrimp growth and survival. The water's ability to withstand pH fluctuations is vital for shrimp development and survival.

Key words: Aquaculture, Litopenaeus vannamei, Water quality analysis.

1. Introduction

India has a vast coastline, which allows for extensive exploitation of marine resource. Fishermen in India used to engage in traditional sea fishing till a few years ago. Fishermen became focused on catching shrimps in the 1970s due to the significant profit margins associated with their export value. The idea of a limitless market demand, high export prices, job creation, and increased foreign exchange profits have pushed several countries in the region rich in aquatic resources to prioritize the development of the shrimp farming business. For successful shrimp forming, achieving optimal water quality is paramount. Water quality parameter is the physical, biological and chemical support in which they carry out their daily processes including as feeding, swimming, spawning, metabolism, development of fish body and excretion, which is an affordable source of protein and acceptability for the distribution and production of fish and other aquatic organisms explicitly or implicitly significant cash crop in many parts of the world (Bronmark and Hansson, 2005).

Water quality characteristics in which all living organisms operate optimally have acceptable limitations. Within these parameters, a rapid decline or increase has negative consequences for essential physiological health of the aquatic organism (Davenport, 1993). Fish are cultured in ponds (lentic water) in the majority of country and other countries, but regrettably, such farmers are unaware need of water quality standards in fisheries and aquaculture. They may acquire maximum fish production in the ponds by using minimum input cost and obtaining a high output of fish yield if they have been properly guided and kept informed of water quality management techniques. Temperature, transparency, turbidity, water colour, carbon dioxide, pH, alkalinity, hardness, ammonia, nitrite, nitrate, primary productivity, biochemical oxygen demand (BOD), plankton population, and primary productivity etc. all play a role for fish production. Hence, it is necessary in order to ensure that these environmental factors are appropriately controlled and regulated in favor for fish survive and growth to their maximum potential.

2. Materials & Methodology

The research is structured around one designated control pond, which serves as the reference point for comparing and evaluating the outcomes observed in the trial ponds. Additionally, three trial ponds have been designated for experimental interventions or modifications, facilitating the exploration of diverse variables and their impact on shrimp culture. The research is planned in duplicate to ensure the robustness and reliability of the findings, while also managing the cost of the research work. By conducting the research in duplicate, we aim to account for potential variability and increase the validity of the results obtained. The dimensions of each pond are meticulously planned to ensure optimal space utilization and facilitate efficient management practices. The surface area of the ponds ranges from 2200 to 2400 square meters, providing ample room for the cultivation of shrimp while allowing for easy access and manoeuvrability within the aquaculture facility. The depth of the ponds is carefully regulated to create an environment conducive to shrimp growth and development. With a uniform depth of 1.2 meters, the ponds offer sufficient water column space to accommodate the shrimp population comfortably while also facilitating water circulation and nutrient distribution throughout the pond ecosystem. The volumetric capacity of each pond is a critical determinant of its carrying capacity and overall productivity. Ranging from 3300 to 3600 cubic meters, the ponds are designed to accommodate the requisite volume of water necessary for sustaining the shrimp population and supporting their biological processes. This substantial volume ensures adequate dilution of waste products and maintenance of water quality parameters within acceptable limits, promoting optimal shrimp health and performance throughout the trial period.

2.1. Water Quality Analysis

Methods for water quality parameters such as pH, dissolved oxygen, alkalinity, nitrites, ammonia and total hardness were checked digital pH meter for pH. Total hardness and calcium was estimated using company and place. For Dissolved Oxygen (D.O), the water sample is fixed at the hatchery itself and analyzed by Winkler's method, Titrimetric method was followed for Alkalinity, Colorimetric method for Ammonia, Azoditization Colorimetric method for nitrites. The water parameters were studied for the samples obtained from healthy and swollen hindgut syndrome (SHG) affected pond. Water samples were collected for 5 hatchery cycles from a hatchery in which after thorough investigations was found to be maintaining good management practices and free of any diseases or infections and analysis for all the water quality parameters were done.

3. Results

Water quality parameters were monitored during the culture operation every month. Data on water quality parameters of control and Experimental ponds were represented graphically (Fig. 1-5) and data on the average values were tabulated in Table 2-6.

3.1. pH

In the present study pH levels that were measured at various time intervals of culture in the control pond and the experimental ponds (which had been treated with water probiotic) varied from 7.7 to 8.5 (control), 7.8 to 8.5 (T1), 7.8 to 8.4 (T2) and 7.4 to 8.5 (T3). There is no increase in pH from first month to sixth month (Table 1; Fig.1). Treated tanks almost maintained pH at eight from first month to sixth month.

Table. 1. pH in L. vannamei by using different feeding combinations in different season in control and experimental ponds

Experimental Time	Control	T1 (E1)	T2 (E4)	T3 (E6)
21-12-2021	8.1	8.3	8.3	8
17-01-2022	8	8.1	8.1	8.3
04-02-2022	8.1	8.3	8.3	8.3
16-02-2022	8.1	8	8	8.2
07-03-2022	8.1	8.2	8.2	8.2
28-03-2022	7.9	8	8.1	8.2
04-04-2022	8.3	8.4	7.8	8.3
11-04-2022	8.2	8.1	8.1	8.3
19-04-2022	8.5	8.2	8.3	8.3
25-04-2022	8.1	8.5	8.4	8
02-05-2022	7.8	7.9	8	7.4
05-05-2022	8	7.8	8	8.5
09-05-2022	7.7		7.9	7.8

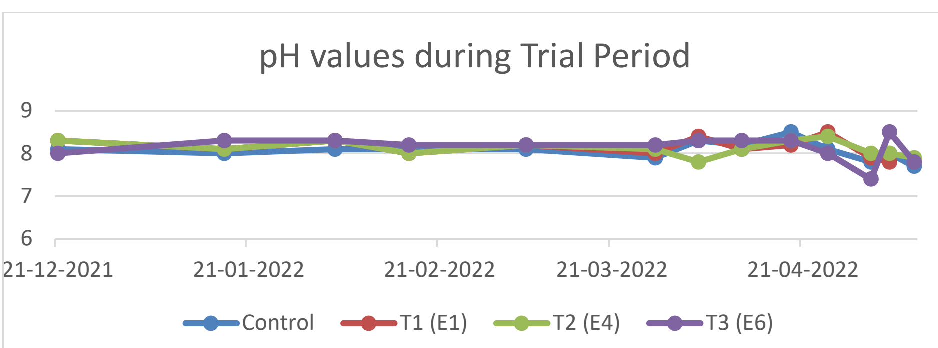

Fig. 1: pH, in treated and control ponds measured during the culture period

3.2 Alkalinity

Our result shown variation in the total alkalinity in control pond and trial ponds with a range between 112ppm to180 ppm for the control pond from first month to sixth month (Table. 2; Fig. 2). Total alkalinity also maintained in optimum range in probiotic treated tanks also shown 120 ppm to 200 ppm for T1, 100 ppm to 200 ppm for T2 and 128 ppm to 184 ppm for T3 from first month to sixth month. Total alkalinity levels (132ppm-184ppm) are maintained at optimum level up to second month and slight decreased in third month (120-168ppm). Alkalinity levels (120ppm- 200ppm) are maintained at optimum level up in fourth month and slight increase (132ppm -184ppm) in fifth month.

Table 2: Alkalinity in L. vannamei by using different feeding combinations in different time interval in control and experimental ponds

Experimental Time	Control (ppm)	T1 (E1) (ppm)	T2 (E4) (ppm)	T3 (E6) (ppm)
21-12-2021	112	136	136	164
17-01-2022	160	120	156	164
04-02-2022	136	144	132	162
16-02-2022	152	172	152	184
07-03-2022	152	120	140	152
28-03-2022	168	132	168	152
04-04-2022	180	140	200	180
11-04-2022	180	200	140	160
19-04-2022	112	180	132	160
25-04-2022	132	160	100	180
02-05-2022	168	164	184	128
05-05-2022	132	152	140	128
09-05-2022	132	142	140	180

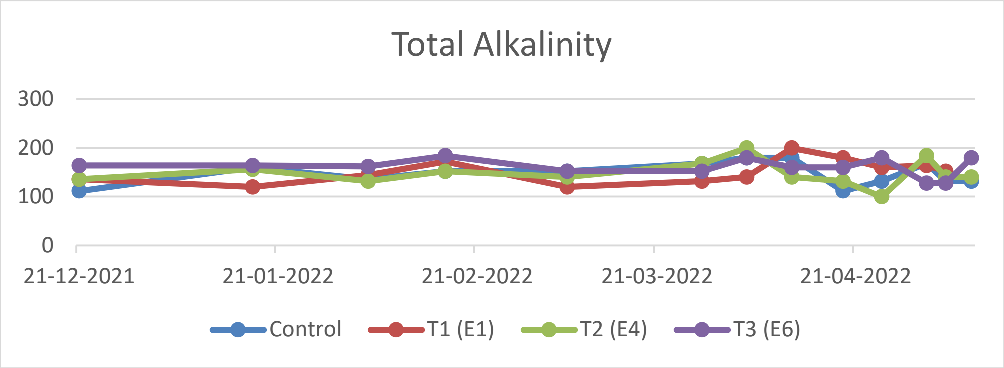

Fig. 2 Alkalinity in treated and control ponds measured during the culture period

3.3. Hardness

Total hardness concentrations in control pond and trial ponds with a range between 860ppm to 2200ppm for the control pond from first month to sixth month (Table.3; Fig.3). Total hardness concentrationsalso maintained in optimum range in probiotic treated tanks also shown 960 ppm to 1910 ppm for T1, 1020 ppm to 2200 ppm for T2 and 128 ppm to 990ppm to 2120ppm for T3 from first month to sixth month. Total hardness concentrations(960ppm-1660ppm) are maintained at optimum level at second month and increase in third month (1240-1410ppm). Hardness concentrationslevels (1700ppm-1860ppm) are maintained at optimum level up in fourth month and slight increase (1840ppm -2200ppm) in fifth month. Our results are not shown much variation in hardness levels between control and treated tanks may be due to constant salinity maintenance.

Table 3: Hardness in L. vannamei by using different feeding combinations in different season in control and experimental ponds

Experimental Time	Control (ppm)	T1 (E1) (ppm)	T2 (E4) (ppm)	T3 (E6) (ppm)
21-12-2021	860	1240	1100	1180
17-01-2022	1280	1380	1210	1410
04-02-2022	1210	1140	1660	990
16-02-2022	1150	960	1020	1100
07-03-2022	1260	1240	1320	1200
28-03-2022	1410	1320	1260	1280
04-04-2022	1460	1570	1680	1800
11-04-2022	1860	1680	1920	1700
19-04-2022	1920	1910	1890	1840
25-04-2022	2100	1760	1840	1820
02-05-2022	2200	1880	2160	1840
05-05-2022	2080	1760	2200	2120
09-05-2022	2060		1940	2000

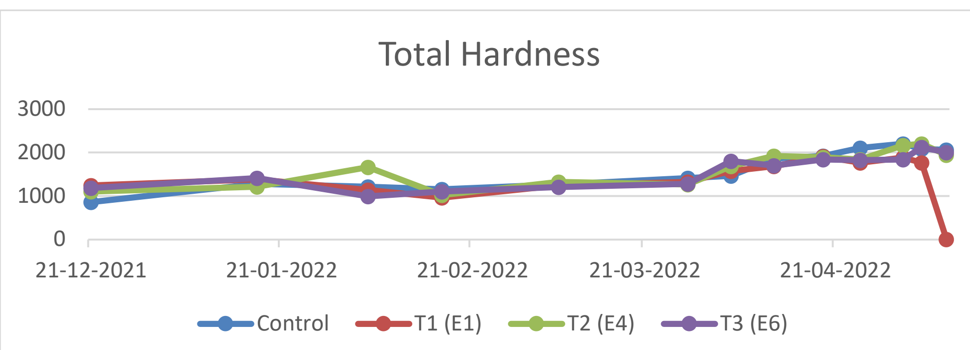

Fig. 3 Hardness in treated and control ponds measured during the culture period

3.4. Ammonia

Total ammonia in the control pond was in the range of 0 to 0.5 ppm and 0 to 0.2 ppm for T1, T2 and T3 ponds. Total ammonia levels were slightly more in control tanks when compared to probiotic treated tanks from first month to sixth month.Similarly, in experimental ponds T1, T2 and T3 were not varied much (0.1ppm -0.2 ppmrespectively) (Table 4; Fig. 4).

Table 4: Ammonia in L. vannamei by using different feeding combinations in different season in control and experimental ponds

Experimental Time	Control (ppm)	T1 (E1) (ppm)	T2 (E4) (ppm)	T3 (E6) (ppm)
21-12-2021	0.1	0	0	0.1
17-01-2022	0.2	0.2	0.2	0.2
04-02-2022	0	0	0	0
16-02-2022	0	0.1	0	0
07-03-2022	0	0.1	0	0
28-03-2022	0	0	0.1	0
04-04-2022	0	0	0	0
11-04-2022	0.5	0.2	0	0.1
19-04-2022	0	0.2	0.1	0
25-04-2022	0	0	0.1	0.1
02-05-2022	2	0.2	0.2	0.2
05-05-2022	0	0.1	0.2	0
09-05-2022	0.2		0.2	0.2

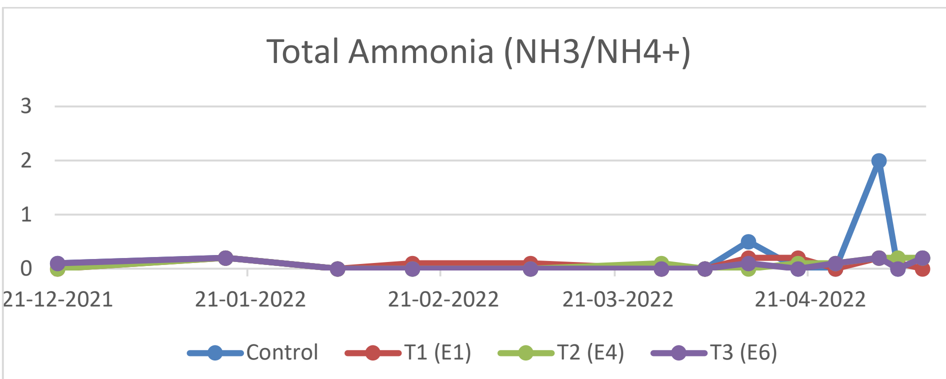

Fig. 4 : Total ammonia in treated and control ponds measured during the culture period

3.5 Nitrite

0 to 0.5 ppm was observed in control pond whereas the experimental ponds have 0 to 0.3 ppm of nitrite (Table. 5; Fig. 5). Nitrite level in the experimental pond (0 to 0.3 ppm) T1 and T4 shown almost similar in experimental time. When compared to treated tanks, control tanks have shown slightly high nitrite levels in fifth month. Nitrite levels almost nil in probiotic treated tanks except in T2 (E4) at fifth month(0.03ppm).

Table 5: Nitrite in L. vannamei by using different feeding combinations in different season in control and experimental ponds

Experimental Time	Control (ppm)	T1 (E1) (ppm)	T2 (E4) (ppm)	T3 (E6) (ppm)
21-12-2021	0	0	0	0
17-01-2022	0	0	0	0

04-02-2022	0	0	0	0
16-02-2022	0	0.1	0	0
07-03-2022	0	0	0	0
28-03-2022	0.1	0	0	0
04-04-2022	0	0	0	0.1
11-04-2022	0.1	0.1	0.1	0
19-04-2022	0	0	0	0
25-04-2022	0	0	0	0
02-05-2022	0.5	0.1	0.1	0.3
05-05-2022	1	0.3	0.3	0
09-05-2022	0		0.1	0.1

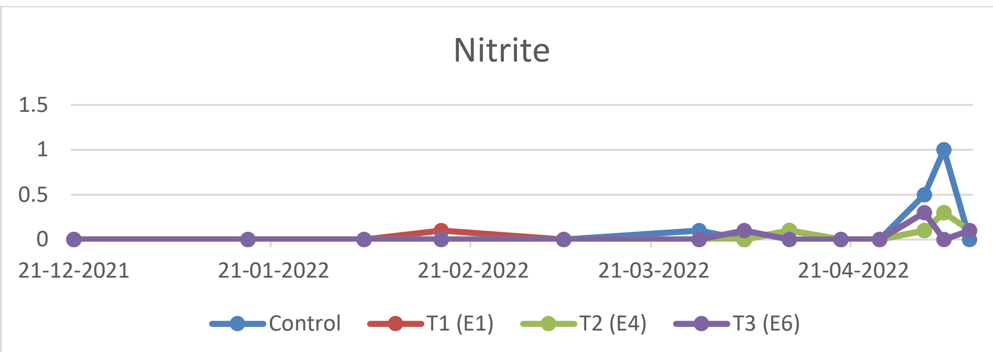

Fig. 5: Nitrite, in treated and control ponds measured during the culture period in water

Discussion

Shrimp culture is one of the major industries earning more foreign exchange because of its market valuein many countries all over the world. A number of chemicals and other substances are used in aquaculture ponds as additives for improving water quality and for controlling biological problems such as phytoplankton blooms, aquatic plant infestation, disease vectors, and proliferation of wild fish (Boyd, 1998). For successful shrimp forming, achieving optimal water quality is paramount. The water quality must be controlled to produce optimal seed growth. Important water quality parameters monitored during the study were, pH, alkalinity, hardness, alkalinity and ammonia levels. pH is an important chemical parameter it disturbs the metabolism and other physiological processes of culture organisms (Boyd and Tucker, 1998). pH is measure of acidity or alkalinity. The optimum range of pH for maximum growth and production should be is normally between 6.8 to 8.7 (Kannupandi et al., 2002; Ramanathan et al., 2005). Our results have shown very little fluctuations in pH from first week to fourth week in both control and treated ponds. In the present study pH levels were closely resembles from 7.4 to 8.5. There is no increase in pH from first month to sixth month. Treated tanks almost maintained pH at eight from first month to sixth month. Wang et al. (2004) and Bachruddin et al. (2017) also stated that the recommended range of pH for L. vannamei culture is 7.6 to 8.6. Similarly, Srinivas et al. (2023) reported that ranges between 7.4-8.5 in the culture ponds.There is a high probability that the good performance of shrimp in culture tanks may be attributed to several factors, including the presence of natural food species in the tanks, such as algae and bacteria, as well as exceptional water quality. It is essential, however, for the health and development of shrimp that the pH level be kept within this ideal range. The shrimp may experience stress if the pH value is outside of this range, which may result in decreased growth, increased susceptibility to illnesses, and even death.

Alkalinity is the capacity of water to neutralize acids without an increase in pH. Alkalinity is the composed of the carbonates and bicarbonate alkalinities. Monitoring the alkalinity of shrimp culture ponds on a regular basis helps to guarantee that the water quality stays within the permitted parameters for the health and production of shrimp. Hardness is a dynamic factor in keeping good pond equilibrium (Boyd and Tucker, 1998). Hardness is used to express the concentration of calcium and magnesium ions in fresh water.Fresh water has 0-55 ppm and may increase up to 211-500 ppm for very hard water. Mineral such as metals, calcium and magnesium, along with their counter ion carbonate include the basis for the measurement of hardness. In our studies we observed less fluctuations in 100 Calcium (Ca+2), Magnesium (Mg+2) and total hardness concentrations in both control and treated tanks starting from first to sixth month. Boyd (1990) also stated that the hardness is related to alkalinity as the cations of hardness and anions of alkalinity are normally derived from the solution of carbonate minerals.

Ammonia concentration depends on pH, temperature and lesser salinity. Organic deposit in the pond will directly influence the accumulation of ammonium and nitrite in the pond because it is transformed by decomposer bacteria into inorganic forms,uneaten feed, feces, dead plankton and airborne debris(Ghaly and Ramakrishnan, 2015). Ammonia is the final product of protein catabolism in crustaceans and can account for 40-90% of nitrogen excretion (Parry, 1960). Devaraja et al. (2002) also reported that the application of probiotic product without affect the microflora of aquaculture, in turn growth of the protein mineralizing and ammonia forming bacterial which help to quicken the decomposition process of the gathered waste materials. Streptomyces could be applied as probiotics, to upgrade the water quality which indirectly improve the growth and yield of the cultured organisms (Kannupandi et al., 2002; Ngan and Phu, 2011)**.** The majority of shrimp species should have their ammonia levels maintained at or below 0.5 mg/L at all times. In the present study also, it was observed that the ammonia concentration in control pond was 0- 0.5ppm, whereas in experimental pond it was 0-0.2ppmobserved. Shrimp might be stressed or even killed by concentrations that are higher.

Nitrite is an intermediate product of nitrification and these are expelled through gills. Nitrite is also produced by decay of organic matter. Nitrite ($NO_2{}^{-2}$) levels exhibited. Nitrite concentrations should be maintained at or below 0.5 mg/L for the majority of shrimp species. Shrimp may be harmed by concentrations that are higher than this certain threshold. Similarly, 0 to 0.5 ppm was observed in control pond whereas the experimental ponds have 0 to 0.3 ppm of nitrite. Nitrite level in the experimental pond (0 to 0.3 ppm) T1 and T4 shown almost similar in experimental time. When compared to treated tanks control tanks have shown slightly high nitrite levels in fifth month. Nitrite levels almost nil in probiotic treated tanks except in T2 (E4)at fifthmonth(0.03ppm).This is due to the beneficial bacteria utilized the dissolved organic matter as their nutrient and for nitrification rapidly. Regular use of commercial probiotics in a shrimp farm in West Java resulted in reduced organic matter accumulation, enhanced water quality and improved environmental conditions (Suhendra et al., 1997; Soundarapandian et al., 2010; Hossain et al., 2013).Studies pertinent to this research indicate consistent pH levels, while notable variations exist in alkalinity (ranging from 100 to 360) and nitrite concentrations (ranging from 0.05 to 27.5) (Makmur et al., 2018; Manan and Putra, 2014; Parlina et al., 2018).

Conclusion

In conclusion, the study highlights the importance of optimal water quality for shrimp growth and survival, highlighting the need for sustainable practices in aquaculture.

Acknowledgement

We the authors of this article hereby acknowledge all the help extended by everyone during the course of this research work.

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