International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 9, Issue 11 -2022

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2022.09.11.002

A perspective study on water quality management in a brackish water shrimp culture system

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Abstract

In India, brackish water aquaculture has been in intensive practice for nearly 3-4 decades with the purpose of meeting the needed demand of sea food across the country and to augment the export trade worldwide. Also, it is helpful to curb overexploitation of the natural resources. However, the issues related to aquaculture industry became obvious in terms of impairment of natural water quality. Hence, it becomes necessary to have a regular monitoring on water quality parameters to ensure the health status of the natural resources (coastal, estuary, back waters, creeks etc). In this backdrop, an assessment was conducted on physical and chemical parameters selecting a brackish water shrimp culture unit. In addition, survival rate and biomass of the cultured shrimps were also examined.The obtained results from the culture system and discharge point were compared to understand the influence of shrimp culture system on altering those parameters. The values of pH, Ammonia, Temperature, Salinity and Dissolved Oxygen were noticed in the range of 7.7-8.6; 0.45-2.0 µmol/l; 29.4-35.3 ^{o}C; 36-40 psu; 3.7-6.2 ppm with the mean values of 8.1; 1.17 µmol/l; 32.07 ^{o}C; 37.2 psu; 4.85 ppm respectively in the culture unit. The values of these parameters were observed in the range of 8.3-9.0; 0.44-1.66 µmol/l; 27.6-32.0 ^{o}C; 32.5-38.0 psu; 3.3-5.2 ppm with the mean values of 8.65; 1.06 µmol/l; 30.3 ^{o}C; 35.6 psu; 4.1 ppm respectively in the discharge point. The results did not exhibit many variations between the stations however, most of the parameters were noticed with lower values except pH in the discharge point these fluctuations be viewed critically as the aquaculture systems release their wastes regularly. The correlation analysis was done between the related parameters to understand their significant influence over others.

Keywords: Brackish Water Aquaculture Unit, Discharge Point, pH, Ammonia, Temperature, Salinity, Dissolved Oxygen (DO), Survival rate, Biomass

1. Introduction

The production of aquaculture has expanded 40 times since 1970, and in the next 50 years, it is predicted to multiple (Avnimelech *et al.,* 2008)[1]. The fastest-growing food industry globally is aquaculture, and its economic significance is rising along with it (FAO, 2008)[4]. Aquaculture of crustaceans, shellfish, and fish, sometimes referred to as "fish," supplies humans with wholesome proteins and supplements the scarce supply from overfished fisheries(Cullis-Suzuki, Sarika& Pauly and Daniel, 2010)[3]. Aquaculture is carried out in open or closed systems in fresh, brackish, and marine waters. Due to concerns about aquaculture's sustainability, international and regional organizations recommended Best Management Practices (BMP) to improve sustainable output. BMPs aim to ecologically responsible aquaculture while also considering social and economic sustainability (FAO, 2008)[4]. Other food-producing industries continue to expand more slowly than aquaculture. Since 1961, worldwide fish consumption has substantially increased at a rate that is twice as high as all meat from terrestrial animals combined (Stankus and Austin, 2021)[13]. China is the world's largest aquaculture nation sharing the aquaculture production by 73.7% in 2016 (Stankus and Austin, 2021)[13].

The physico-chemical parameters are the crucial tools for determining the water quality and ecological health (Florescu *et al.,* 2011)[5]. Therefore, it is imperative to keep the aquatic ecosystem healthy for sustainable use by the living resources and for the aquaculture practices themselves. To provide a reliable route for sustainable growth, several environmental criteria and their intricate connections with various substances should be taken into consideration (Lovchinov *et al.,* 2006)[7]. Hence this study is conducted to ascertain the Best Management Practices in a brackish water aquaculture unit through assessing the vital parameters in culture system as well as in the discharge point (SCS aquaculture pond, Chandrapadi village, Nagapattinam district).

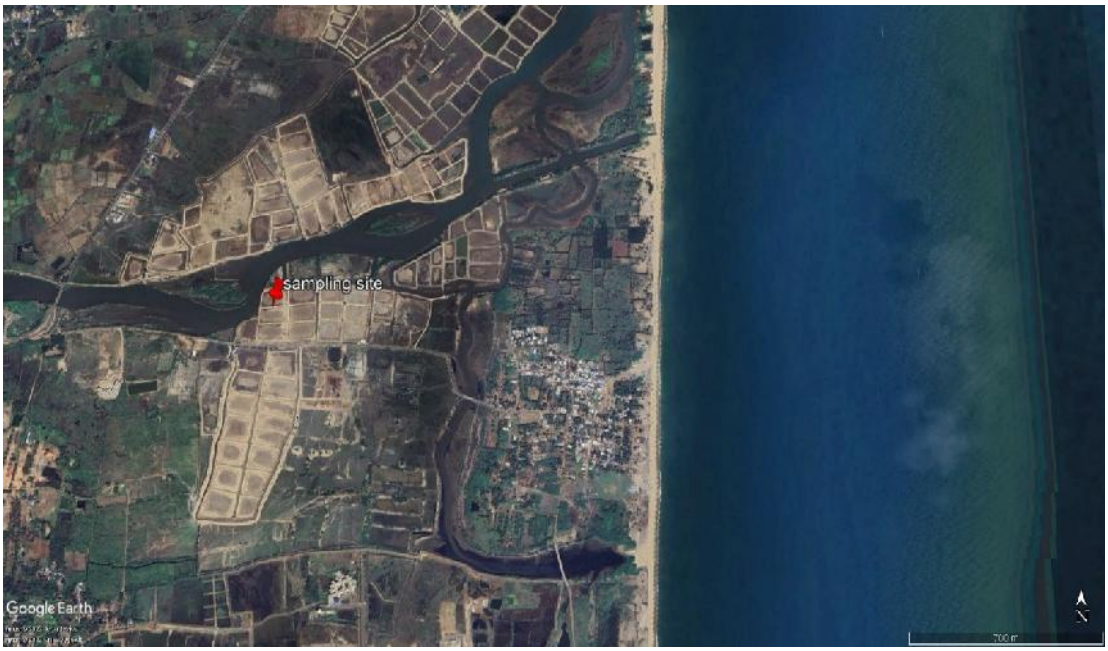

Fig.1 Map showing the brackish water shrimp culture pond at Chandrapadi village, Nagapattinam district, Tamil Nadu, India.

Aquatic organisms can experience stress when the environment is not suitable. Low feeding and growth rates are produced by high stress levels, which also encourage the emergence of disease in organisms. Any aquaculture growing operation needs adequate water quality conditions. Aquatic species' ability to reproduce, develop, and survive is influenced by water quality. The standards for

evaluating water quality are clearly specified by acceptable limits and rely on the type of organisms that will be investigated. Soil and water make up the ecology of a shrimp pond; the primary variables influencing shrimp organisms are employed as water quality criteria. However, if ponds are properly monitored and managed, maintaining high water quality standards, the adverse consequences are lessened (Boyd CE and Tucker CS, 1992)[2]. According to Ramesh *et al.* (2010)[11], a Water Quality Index (WQI) is a mathematical tool that is used to summaries huge quantities of water quality data into a single value that can be used to analyze the behavior of the water quality parameters involved in shrimp culture.

2. Materials and Methods

The samples were collected by following the standard protocol from 10th March to 30th June 2022 by Niskin water sampler at 0.5-meter depth without disturbing the pond water of *Litopenaeus vannamei* shrimp culture unit and from the discharge point. The Surface Water Temperature (SWT), pH, and Salinity were measured in the field itself by a calibrated water quality instrument (Model: Quanta-Qd04193). The collected water samples were transferred gently to the DO (Dissolved Oxygen) bottles without making air bubbles. The samples were fixed by adding magnesium sulphate and alkaline iodide in the field and brought to the laboratory for the estimation of dissolved oxygen (DO) by following the Winkler's titration method and the ammonia in the water samples were also assessed (Grasshoff *et al.*, 1999b)[6] since it is the waste product of culture organisms.

3. Results

The water samples from the culture pond and from the discharge point were collected on weekly basis. The range and mean values obtained from the culture system and discharge point were shown in figures 2-5. The values of Surface Water Temperature, Salinity, Dissolved Oxygen, pH and Ammonia were noticed in the range of; 29.4-35.3^{o}C; 36-40psu; 3.7-6.2ppm; 7.7-8.6; 0.45-2.0µmol/l with the mean values of; 32.07^{o}C; 37.2psu; 4.85ppm; 8.1; 1.17µmol/l respectively in the culture unit. The values of those parameters were observed in the range of 27.6-32.0^{o}C; 32.5-38.0psu; 3.3-5.2ppm; 8.3-9.0; 0.44-1.66µmol/l with the mean values of 30.3^{o}C; 35.6psu; 4.1ppm; 8.65; 1.06µmol/l respectively in the discharge point. Upon 113 days of culture period, about 80% of the survival rate was noticed and the obtained biomass was 10125 kg (Table 1).

Table 1. Survival rate and measured biomass in the brackish water shrimp (*Litopenaeus vannamei*) culture pond.

Date	No.of. Days	Survival rate	Biomass
10th March	1	100%	
14th March	5		
21st March	12		
28th March	19	95%	
4th April	26		
11th April	33		
19th April	41	90%	
27th April	49		1920
3rd May	55		3220
12th May	64		4275
20th May	72	85%	5250
29th May	81		6090
5th June	88		7140
13th June	96		8190
22nd June	105		9450
30th June	113	80%	10125

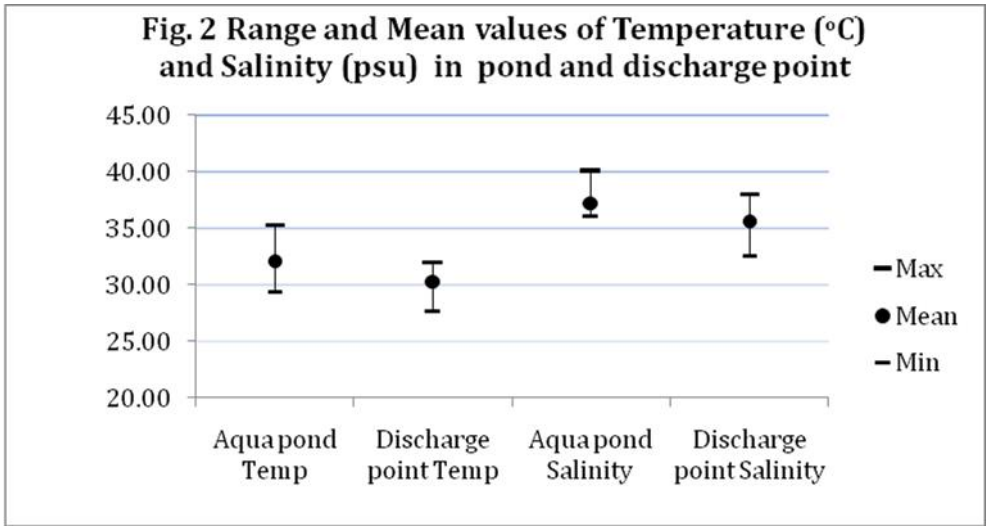

Fig. 2 Range and Mean values of Temperature (°C) and Salinity (psu) in pond and discharge point

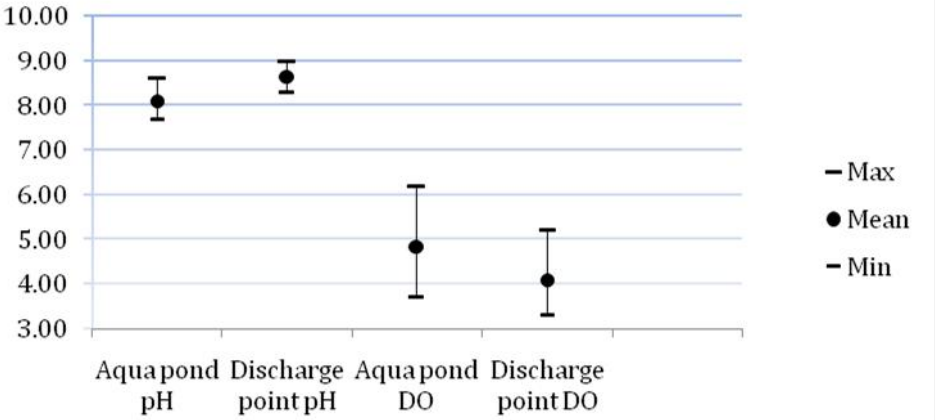

Fig. 3 Range and Mean values of pH and Dissolved Oxygen (ppm) in pond and dischrge point

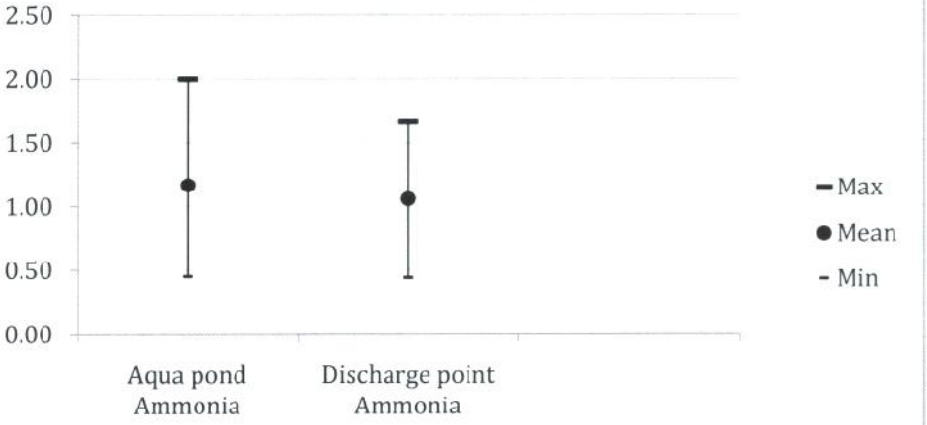

Fig. 4 Range and Mean values of Ammonia µmol/l in pond and discharge point

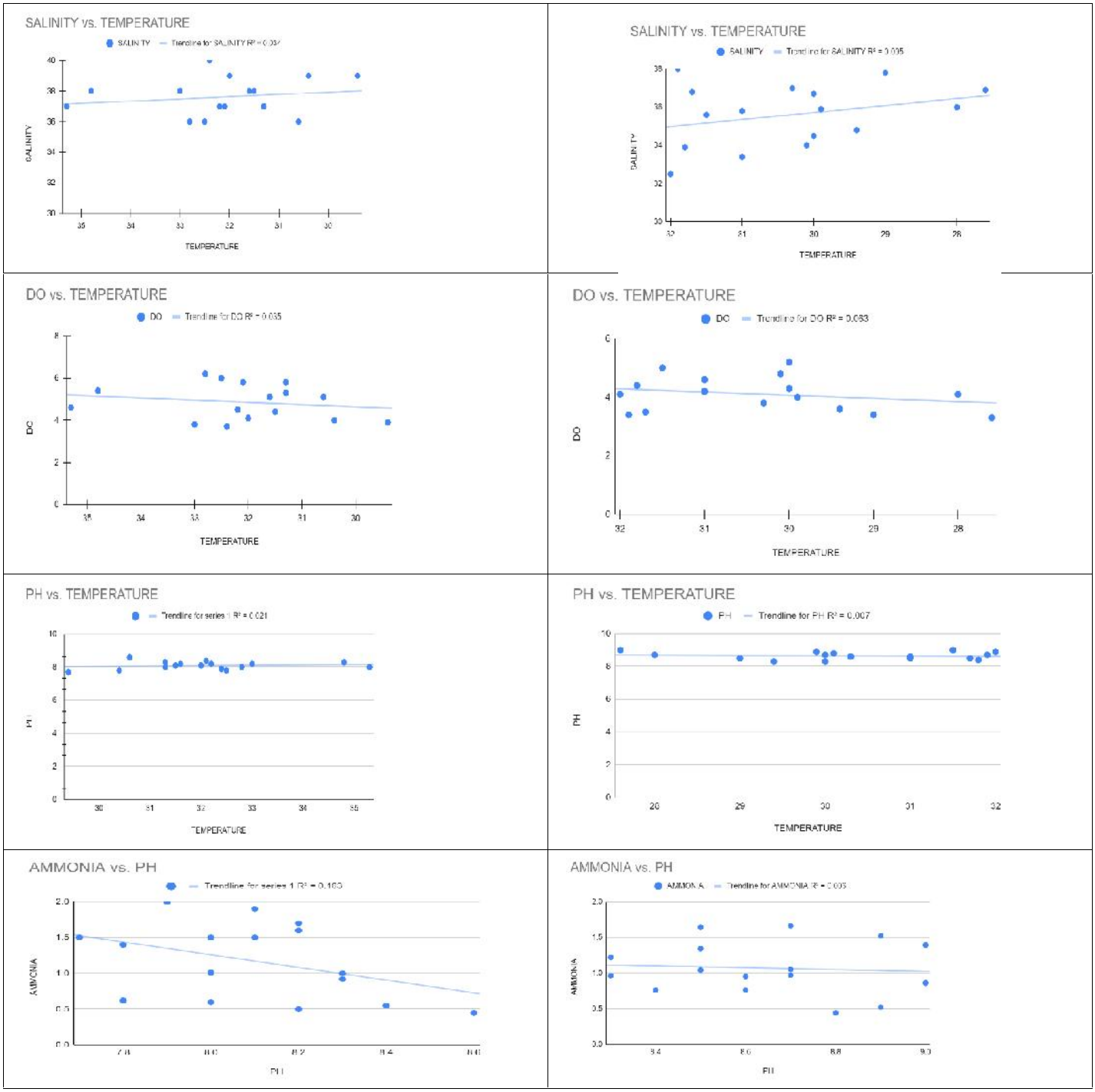

Fig 5. Correlation between the temperature and other parameters such as salinity, DO and pH and between Ammonia and pH assessed for culture pond (Figures in left) and discharge point (Figures in right)

4. Discussion

The health of the aquatic environment is mostly governed by its physical, chemical and biological properties (Marcel Martinez-Porchas and Luis R Martinez-Cordova, 2012)[8]. The surface water temperature is one of the most significant ecological elements since its high range accelerates the metabolic activities and lower range stresses them into dormancy state. So, it controls the physiological behavior and distribution of species including plankton.

A narrow range of temperature was found during this period with an average of 31°C. Hence, the present observations on the temperature variation would not affect the pond and natural ecosystems. Likewise, the salinity is also one of the important parameters that help in controlling the osmo-regulatory balances among the aquatic animals. As far as the recorded level of salinity is concerned, it was found as optimal range (36-40 psu) and would not create any threat to the ecosystem. The amount of dissolved oxygen (DO) is crucial that also indicates the pollution status of an aquatic ecosystem. The normal level of DO in the natural aquatic environment is 4-6 mg/l and the obtained value of DO during this study period was noticed within the normal range with an average level of 4.47 mg/l and it showed that the pond water was well mixed and aerated throughout the culture period. Among the assessed parameters, the pH showed slightly significant variation between these stations showing lesser values at culture pond (7.7-8.6) when compared to discharge point (8.3-9.0). This reiterates that the pond water receives the wastes from the animal and food wastes that settle down and reducing its pH. However, pH showed at elevated alkaline level that would not harm the aquatic life and it showed that the culture system followed good maintenance of pH in terms of lime application whenever required. Ammonia is a waste product of culture organisms and also as nutrient that includes both hydrogen and nitrogen. Unionized chemically, it has the formula NH_3, whereas ionized chemically; it has the formula of NH_4+. Total ammonia is the sum of NH_3 and NH_4+. The average ammonia concentration in the aquatic pond was 1.1 µmol/l and the discharge point was 1.06 µmol/l that showed higher than the normal level of natural aquatic ecosystem (0.1µmol).

The correlation between the temperature and other parameters such as salinity (r^2=0.034; r^2=0.095), dissolved oxygen (r^2=0.035; r^2=0.063), pH (r^2=0.021; r^2=0.007) for the culture pond and for the discharge point showed no significant negative influence each other whereas the assessment showed slightly positive correlation which specified that the narrow range of parameters maintained in the study area. However, between pH and ammonia in the aquatic pond (r^2=0.163) showed a significant positive correlation whereas in the discharge point(r^2=0.006), it showed insignificant positive correlation. It is clearly indicating that the discharge of waste in the form of ammonia at the culture pond reduces the pH while this concentration was diluted when discharged into the natural system.

To produce healthy aquaculture products and to progress lucratively and efficiently, water quality management is most significance. In any aquatic system, environmental parameters such as temperature, salinity, pH, and dissolved oxygen all play a part in the aquaculture pond and to maintain its quality, the treatment system is important to lessen its impact in natural waters (Otte and Rosenthal, 1979)[10]. Since the culture pond is a small space, it is mandatory to maintain the ideal water quality parameters (temperature 27-31^{o}C; salinity 14-25 psu; pH 7.8-8.6; and DO 5.1-5.9 ppm) during the culture period. The poor maintenance of water quality is not only reducing the growth rate but also paves ways for proliferation of pathogens in culture organisms and spoil their heath. Therefore the good maintenance involves proper aeration, feed management, water exchange and lime treatment at regular basis. According to Sharmila *et al.* (1996)[12], the bacterial load might have occurred if the culture pond is allowed for the organic waste deposition at the bottom. The shrimp culture is often detrimental because microbes invade the culture organisms easily which leads to stress and sickness (Moriarty, 1998)[9].

Summary and Conclusion

Generally, aquaculture industry releases heavy organic load arising out of wastes from culture organisms and food wastes. Therefore, a proper management of aquaculture practices is need of the hour to keep the natural aquatic environment healthy. In one way this industry needs to be developed to meet the food demand and in other way, it becomes more significant to have proper

management system to avoid any form of contamination created by this industry. Therefore to understand the health status of the environment, the essential physico-chemical parameters must be monitored regularly and appropriate measures needs to be taken whenever there is a deviation in the normal levels. Hence, for the present study, a brackish water shrimp culture unit was selected (SCS Aquaculture Ltd., Chandrapadi village, Nagapattinam district, Tamil Nadu) and the vital physico-chemical parameters such as surface water temperature, salinity, dissolved oxygen, pH and ammonia were analyzed for the entire culture period in the culture pond and its discharge point. The assessed parameters were statistically analyzed to understand their relationship. The water quality parameters did not exhibit wide deviations between the stations as all the parameters were noticed with narrow range with normal levels. However, lower values of pH in the discharge point and higher values of ammonia need to be viewed critically as the aquaculture systems release their wastes regularly. Except pH and ammonia, other parameters were not found with significant positive correlation as pH and ammonia have influence on each other.

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DOI:10.22192/ijarbs.2022.09.11.002	

How to cite this article:
Rengasamy Seetharaman, Saravanan Kumaresan, Subramanian Bragadeeswaran, Neyasudeen Inayathullah, Srinivasan Srikavibharathi, Thavamani Sasidharan, Balamurugan Visnu, Jahabar Ali Mohamed Asarudeen. (2022). A perspective study on water quality management in a brackish water shrimp culture system. Int. J. Adv. Res. Biol. Sci. 9(11): 6-13.
DOI: http://dx.doi.org/10.22192/ijarbs.2022.09.11.002