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Observations on Soil, Water and Biological Conditions of Shrimp Farms

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Abstract

In the present study, three shrimp farms were selected along the Kandaleru creek at Pudiparthi area of Nellore District of Andhra Pradesh and one, seawater based farm at Taruvaikulam area of Tuticorin, Tamil Nadu where shrimp culture was being practiced. Samples of soil, water, plankton and benthos were collected from the shrimp culture ponds at monthly intervals during the culture period. The soil and water quality parameters were found to be within safe permissible levels. Textural class of soil was sandy clay loam and clay loam, which are suitable for brackishwater aquaculture. Plankton bloom and benthos at both the places were moderate. The bacterial population in water in shrimp farm was found to be relatively very high at the time of harvest period (235 nos. x $10^4 ml^{-1}$) than during the culture (31-77 nos. x 10^4 ml^{-1}) and the population of bacteria in the soil sample was higher during culture period (44-57 nos. x $10^4 ml^{-1}$) than at the harvest time (26 nos. x $10^4 ml^{-1}$).

Key words: Shrimp culture, Soil and water quality, Biological condition

Introduction

Shrimp farming activity has been identified as one of the key areas for enhancing shrimp production and has been gaining importance in India for the past few years. The interaction of inputs such as shrimp seed, feed etc. with ambient water results in growth and production of shrimp and changed water quality (Gupta et al., 2001; Krishnani et al., 1997). The unutilized feed and feces shed by shrimp are likely to increase the concentration of nutrients, plankton and suspended solids and alter bottom soil conditions (Boyd, 1995). Some species of benthic algae are highly toxic and hinder movement of shrimp and compete for oxygen and algae aid sedimentation and pond bottom degradation. These are all potential factors contributing to stress on the shrimp and initiate disease outbreak. Dense phytoplankton blooms as net consumers of oxygen should be of greater concern than their role as oxygen producers. The present study was taken up to assess the changes in water, soil and biological characteristics of shrimp farms at Pudiparthi area of Andhra Pradesh and Taruvaikulam area of Tamil Nadu in south India during April to August, 1993.

Materials & Methods

Three shrimp farms were selected along the Kandaleru Creek at Pudiparthi, Nellore District, Andhra Pradesh and one, seawater based farm at Taruvaikulam, Tuticorin, Tamil Nadu. Samples were collected from each farm at monthly intervals during one cycle of culture period (April to August, 1993). Water and soil samples were analysed by following standard methods (Strickland & Parsons, 1972; APHA, 1980; Piper, 1966 and Jackson, 1967). The Bacterial population in the samples was determined by serial dilution and spread plate identified on their biochemical reactions. Plankton and benthos samples were collected as per standard methods.

Results & Discussion

The details regarding the farms and operational details are presented in Table –1. At creek based shrimp farm at Nellore, *Penaeus monodon* was being stocked @ 20,000, 24000 and 28,000 post larvae ha^{-1} and the production was found to be 3, 6 and 5 tons ha^{-1} respectively. Imported feed was used in all the farms. At seawater based shrimp farm of Taruvaikulam, both *P. monodon* and *P. indicus* species were cultured with the stocking density of 40,000 ha^{-1} and 70,000 ha^{-1}

respectively and the production was 4.5 and 8 tons ha^{-1}.

Water characteristics

Results of the analysis of water and soil samples

Table 1. Details of Brackishwater shrimp farms in Nellore, Andhra Pradesh and Taruvaikulam in Tamil Nadu.

Location of the Farm	Water source	Area of farms (ha)	No. of ponds	Species cultured
Taruvaikulam, Tutuicorin Tamil Nadu	Sea	26.0	53	*P.indicus* *P.monodon*
Pudiparthi Nellore Dt. Andhra Pradesh	Kandaleru Creek	5.86	11	*P.monodon*
	"	42.0	56	*P.monodon*
	"	18.0	20	*P.monodon*

Table-2: Water and soil characteristics in shrimp farms at Nellore (Average of 9 Ponds along with Standard Deviation) along with standard deviation

Parameters	WATER			
WATER	April 1993	May 1993	June 1993	Augu st 1993
Temp (°C)	28.6 (±1.4)	30.3 (±1.1)	29.3 (±0.9)	30.0 (±0.8)
pH	8.0 (±0.8)	8.0 (±0.9)	8.0 (±0.5)	8.4 (±0.7)
Turbidity (NTU)	6 (±0.8)	10 (±1.2)	11 (±1.8)	45 (±3.5)
Alkalinity ($mg\ l^{-1}$)	140 (±5.8)	151 (±7.2)	152 (±6.7)	161 (±8.4)
T.S.S ($mg\ l^{-1}$)	16 (±1.4)	49 (±3.2)	49 (±4.8)	58 (±4.2)
Salinity (%0)	17.0 (±1.0)	26.1 (±1.8)	26.8 (±2.1)	26 (±1.5)
D.O ($mg\ l^{-1}$)	6.3 (±1.1)	6.9 (±1.6)	5.9 (±0.9)	5.8 (±1.1)
COD ($mg\ l^{-1}$)	10.2 (±1.4)	18.8 (±1.8)	18.3 (±2.1)	34.1 (±3.9)
BOD5 ($mg\ l^{-1}$)	7.0 (±0.9)	12.8 (±1.1)	12.0 (±1.8)	19.0 (±2.1)
NO2 ($mg\ l^{-1}$)	0.04 (±0.01)	0.04 (±0.01)	0.05 (±0.02)	0.07 ±0.02)
NO3 ($mg\ l^{-1}$)	0.09 (±0.02)	0.15 (±0.04)	0.17 (±0.03)	0.20 ±0.04)
Total Ammonia-N ($mg\ l^{-1}$)	0.16 (±0.03)	0.18 (±0.04)	0.18 (±0.03)	1.2 (±0.3)
NH3-N ($mg\ l^{-1}$)	0.008 (±0.002)	0.009 (±0.001)	0.009 (±0.003)	0.15 (±0.03)
Total N($mg\ l^{-1}$)	0.26 (±0.09)	0.38 (±0.08)	0.48 (±0.09)	1.9 (±0.2)
PO4 ($mg\ l^{-1}$)	0.004 (±0.001)	0.05 (±0.008)	0.09 (±0.01)	0.11 (±0.02)
Total P ($mg\ l^{-1}$)	0.08 (±0.02)	0.12 (±0.04)	0.18 (±0.05)	0.20 (±0.08)
H2S ($mg\ l^{-1}$)	BDL	BDL	BDL	BDL
SOIL				
Sand (%)	40.9 (±4.8)	41.1 (±5.4)	41.1 (±6.2)	41.5 (±4.2)
Silt (%)	12.3 (±3.4)	12.5 (±2.8)	13.3 (±2.4)	13.7 (±3.1)
Clay (%)	46.8 (±4.2)	46.4 (±5.8)	45.6 (±4.4)	44.8 (±5.2)
pH	6.7 (±0.8)	6.8 (±0.6)	6.9 (±0.7)	6.2 (±0.8)
Eh (mV)	-40 (±7)	-106 (±10)	-126 (±12)	-154 (±15)
EC (dS/m)	17.1 (±3.1)	26.6 (±2.9)	29.0 (±2.8)	28.8 (±4.1)
Organic Carbon (%)	0.34 (±0.12)	0.42 (±0.18)	0.52 (±0.14)	0.8 (±0.2)

BDL -→ Below Detection Limit

in creekwater and seawater based shrimp farms are presented in Table-2 and 3 respectively. The results show that salinity and temperatures differed slightly between various months and were mostly related to seasonal influences. The water was alkaline (pH 8.0-8.4) at the end of the culture period. Turbidity and total suspended solids (TSS) increased gradually from 6 to 45 NTU and 16 to 58 mg l^{-1} respectively. The dissolved oxygen (DO) ranged from 6.3 mg l^{-1} during the start of the culture to 5.8 mg l^{-1} at the end of the culture period.

The increase in organic matter was evident from the increase of COD values of 10.2 to 34.1 mg l^{-1} and 5-day biochemical oxygen demand of 7.0 to 19.0 mg l^{-1}. The concentration of nitrite-nitrogen, nitrate-nitrogen and free ammonia-nitrogen changed from 0.04 to 0.07 mg l^{-1}, 0.09 to 0.20 mg l^{-1}, 0.008 to 0.150 mg l^{-1} respectively during the culture period, the maximum values being observed at the end of the culture. Total N and total P changed from 0.26 and 0.08 mg l^{-1} at the start to 1.9 and 0.20 mg l^{-1} respectively at the end of the culture. Hydrogen sulphide was not detected during the culture period.

There was a gradual increase in all water-quality parameters except for DO, during culture period. However, all water quality parameters were found to be within safe permissible levels (Chen & Lei, 1990 and MOEF, 1993).

In seawater based farm, water parameters such as pH, alkalinity, salinity and DO did not vary much and they ranged from 8.2-8.3, 90-105 mg l^{-1}, 32.5-36.6 ‰ and 6.8-7.8 mg l^{-1} respectively. Other water quality parameters such as turbidity, TSS, COD, BOD_5, total ammonia nitrogen, nitrite, nitrate, total N, phosphates and total P increased from 7.3 to 22.8 NTU, 40 to 98 mg l^{-1}, 10.6 to 15.1 mg l^{-1}, 8 to 12 mg l^{-1}, 0.11 to 0.16 mg l^{-1}, 0.04 to 0.06 mg l^{-1}, 0.13 to 0.20 mg l^{-1}, 0.26 to 0.84 mg l^{-1}, 0.03 to 0.07 mg l^{-1} and 0.10 to 0.40 mg l^{-1} respectively. However, all the parameters were within safe permissible levels (Chen & Lei, 1990 and MOEF, 1993).

Soil Characteristics

During the culture period at Nellore, redox potential, electrical conductivity and organic

carbon in soil increased from -40 to –154 mV, 17.1 to 29 dS m^{-1} and 0.34 to 0.8% respectively.

Table-3: Water and Soil Characteristics in Shrimp Farm at Tuticorin (Average of 6 Ponds along with Standard Deviation).

Parameter	WATER			
	April 1993	May 1993	June 1993	August 1993
Temp (°C)	28 (±0.9)	28.3(±1.2)	26.8(±0.7)	26.0 (±0.7)
pH	8.2 (±0.4)	8.3 (±0.3)	8.3 (±0.6)	8.3 (±0.4)
Turbidity (NTU)	7.3 (±1.1)	8.0 (±1.0)	10.5 (±1.4)	22.8 (±2.8)
Alkalinity (mg l^{-1})	90 (±5)	104 (±8)	105 (±7)	105 (±9)
T.S.S (mg l^{-1})	40 (±3)	46 (±5)	67 (±4)	98 (±8)
Salinity (‰)	32.5 (±1.2)	35.3 (±0.9)	34 (±1.5)	36.6 (±1.3)
D.O (mg l^{-1})	7.8 (±1.1)	7.6 (±0.8)	7.0 (±0.7)	6.8 (±1.1)
COD (mg l^{-1})	10.6(±1.2)	13.6 (±0.9)	14.3 (±1.5)	15.1 (±1.4)
BOD5 (mg l^{-1})	8.0 (±0.9)	9.6 (±1.2)	9.8 (±1.6)	12.0 (±1.5)
NO2 (mg l^{-1})	0.04(±0.01)	0.04(±0.02)	0.05(±0.01)	0.06(±0.02)
NO3 (mg l^{-1})	0.13(±0.08)	0.20(±0.05)	0.18 (±0.04)	0.20(±0.05)
Total Ammonia-N (mg l^{-1})	0.12(±0.04)	0.11(±0.03)	0.15 (±0.04)	0.16(±0.03)
NH3-N (mg l^{-1})	Trace	Trace	0.01(±0.008)	0.12(±0.03)
Total N (mg l^{-1})	0.26(±0.08)	0.40(±0.09)	0.62 (±0.11)	0.84(±0.15)
PO4 (mg l^{-1})	0.03(±0.01)	0.05(±0.02)	0.06 (±0.02)	0.07(±0.03)
Total P (mg l^{-1})	0.10(±0.03)	0.16(±0.04)	0.20 (±0.03)	0.4 (±0.09)
H2S (mg l^{-1})	BDL	BDL	BDL	BDL
SOIL				
Sand (%)	66.1 (±6.1)	65.5 (±7.8)	64.5 (±5.2)	64.3 (±6.4)
Silt (%)	13.5 (±1.4)	14.0 (±1.9)	15.1 (±2.4)	17.2 (±2.7)
Clay (%)	20.4 (±2.8)	20.4 (±2.1)	20.4 (±3.2)	16.8 (±1.9)
pH	7.2 (±0.9)	70 (±0.6)	6.8 (±0.6)	6.8 (±0.5)
Eh (mV)	-42 (±7)	-60 (±6)	-73 (±5)	-80 (±9)
EC (dS/m)	14.0 (±2.1)	15.6 (±1.9)	19.9 (±2.1)	16.5 (±1.9)
Organic Carbon (%)	0.17(±0.08)	0.18(±0.09)	0.18 (±0.04)	0.36(±0.11)

BDL -→ Below Detection Limit

Soil pH was slightly acidic to neutral (pH 6.2-6.9), whereas, in Tuticorin, during the culture period, variation in pH, redox potential, electrical conductivity and organic carbon in soil was not significant and they ranged from 6.8-7.2, -42 to –80 mV, 14 to 19.9 dS/m and 0.17 to 0.36% respectively.

Texture of the soil has direct bearing on the productivity of the ponds. In brackishwater shrimp ponds, benthic productivity is more important than the production of plankton. A clayey soil rich in organic matter encourages the growth of benthic blue algae, which along with the associated micro-organisms form the main food of most of the brackishwater animals. Clayey soils are best suited for constructing bunds and have good water retention properties. Such bunds cannot be easily eroded by wave or tidal action. Sandy soil is porous and very poor material for constructing bunds. Therefore, brackishwater soils with moderately heavy textured are ideal for aquaculture. Sandy clay, sandy clay-loam and clay-loam are some of the textures suitable for aquaculture. At Nellore, soil was clay-loam as sand, silt and clay ranged from 40.9-41.5%, 12.3-13.7% and 44.8-46.8%, whereas, at Tuticorin, soil was sandy clay-loam as sand, silt and clay were in the range of 64.3-66.1%, 13.5-17.2% and 16.8-20.4% respectively.

Table-4: Occurrence of plankton and benthos in shrimp farm at Nellore (average of 9-ponds along with standard deviation)

Species	April 1993	May 1993	June 1993	August 1993
Phytoplankton (Nos/ml)				
1. Nitzschia. Sp.	-	-	16 (±3)	45 (±6)
2. Pleurosigma sp.	113 (±9)	-	-	43 (±5)
3. Filamentous algae	-	800 (±34)	80 (±9)	333 (±15)
Zooplankton (Nos/l)				
1. *Copepods*	233 (±14)	270 (±19)	185 (±19)	145 (±16)
2. *Cladocerans*	-	182 (±21)	54 (±5)	23 (±4)
3. *Mysids*	50 (±8)	-	60 (±9)	-
4. Crustacean nauplii	83 (±11)	50 (±8)	13 (±4)	106 (±8)
5. Fish & Prawn eggs	101 (±9)	-	163 (±21)	53 (±9)
6. Rotifers	-	-	60 (±8)	93 (±10)
Benthos (nos/m^2)				
1. Gastropods	622 (±41)	377 (±38)	716 (±52)	163 (±21)
2. Polychaetes	445 (±21)	-	-	44 (±5)
3. Amphipods	67 (±9)	22 (±5)	233 (±19)	7 (±2)
4. Bivalves	144 (±17)	67 (±5)	55 (±7)	-
5. Fish juveniles	-	22 (±3)	-	-
6. Prawn juveniles	-	22 (±7)	-	29(±5)

Table-5: Occurrence of plankton and benthos in shrimp farm at Tuticorin (average of 6-ponds along with standard deviation)

Species	April 1993	May 1993	June 1993	August 1993
Phytoplankton (Nos. ml^{-1})				
1. *Nitzschia.* Sp.	30 (±6)	195 (±12)	-	35 (±8)
2. *Pleurosigma* sp.	142 (±12)	-	35 (±5)	75 (±6)
3. *Coscinodiscus* sp.	23 (±4)	-	-	25 (±3)
Zooplankton (Nos. l^{-1})				
1. Copepods	90 (±6)	125 (±8)	35 (±5)	105 (±14)
2. Cladocerans	-	-	45 (±5)	5 (±1)
3. Mysids	36 (±7)	-	25 (±4)	-
4. Crustacean nauplii	-	-	20 (±3)	75 (±6)
Benthos (nos. m^{-2})				
1. Gastropods	367 (±13)	18 (±2)	-	16 (±3)
2. Polychaetes	133 (±8)	9 (±3)	-	8 (±2)
3. Amphipods	73 (±6)	-	69 (±8)	-

Plankton and benthos population

The abundance of plankton and benthos in shrimp farms at Nellore and Tuticorin is given in Tables 4 and 5. Filamentous algae, *Nitzschia* and

Pleurosigma species were the major group in shrimp farm at Nellore, whereas, filamentous algae were not found in the shrimp farm at Tuticorin but *Nitzschia*, *Pleurosigma* and *Coscinodiscus* species were prominent. Phytoplankton blooms in both the places were moderate and all the samples showed more or less uniform species composition.

In Nellore shrimp farm, major zooplankton species were Copepods, Mysids, Crustacean nauplii and Cladocerans, whereas in shrimp farm at Tuticorin, beside these species, fish and prawn eggs and rotifers were also found. Different groups of benthic animals were identified, counted and separated. Major groups of macrobenthos observed were gastropods, polychaetes and amphipods. These species were found to be more in Nellore shrimp farm as compared to those at Tuticorin.

Bacterial populations

The bacterial population in water and soil in the shrimp farms at Pudiparthi and Tuticorin areas is presented in Table 6. The result indicates that in shrimp farms at Nellore, the bacterial population in water was higher during harvest time than during culture period, whereas, in soil, bacterial population was found to be higher during the culture period than at the time of harvest. This may be due to the disturbance of the pond bottom during harvest wherein the bacteria may be pushed on to the water phase from the soil. The entero pathogenic bacterium *Salmonella* could not be isolated from any of the samples collected from these farms. The heterotrophic bacterial flora of these farms did not vary much in the species composition.

Table 6. Bacterial population in shrimp farms (average of 9-ponds along with standard deviation)

Bacterial population	April 1993	May 1993	June 1993	August 1993
Pudiparthi, Nellore, Andhra Pradesh				
1. Water (no x 10^4 ml^{-1})	77 (±6)	39 (±4)	31 (±5)	235 (±11)
2. Soil (no x 10^6 ml^{-1})	57 (±5)	44 (±4)	49 (±6)	26 (±3)
Taruvaikulam, Tuticorin, Tamil Nadu				
1. Water (no x 10^4 ml^{-1})	23 (±4)	360 (±14)	69 (±8)	99 (±8)
2. Soil (no x 10^6 ml^{-1})	30 (±3)	47 (±5)	97 (±6)	136 (±9)

The bacteria found in these farms are *Pseudomonas*, *Aeromonas*, *Vibrio*, *Flavobacterium*, *Acinetobacter*, *Moraxella*, and *Bacillus etc*.

From the present study conducted in shrimp farms at Andhra Pradesh and Tamil Nadu, it is concluded that soil and water quality were being maintained properly at both the places. All parameters were found to be within safe permissible levels. Textural class of soil was sandy clay-loam and clay-loam, which are suitable for brackishwater aquaculture. Plankton bloom and benthos at both the places were moderate. The bacterial population in water in shrimp farm was found to be relatively very high during the culture period than at the time of harvest and the population of bacteria in the soil sample was higher at the harvest time than during culture period. Due to proper soil and water quality management towards reduction of stressors, occurrence of disease and mortality have been efficiently prevented with the high shrimp production ranging from 3-8 tons ha^{-1}.

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