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Comparative Study of Water Quality in Extensive and Modified Extensive *Penaeus monodon* (Fabricius) Culture Systems in South West Coast of Kerala

KEYWORDS: Brackishwater shrimp ponds, extensive system, modified extensive system, *Penaeus monodon*, shrimp culture, water quality

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ABSTRACT *Water quality characteristics of extensive and modified extensive Penaeus monodon culture systems on the southwest coast of Kerala, was studied. Extensive and modified extensive systems differed significantly, particularly in regard to such important water quality parameters as pH, salinity, DO, CO_2, H_2S, NH_3, alkalinity and hardness. Positive correlation between salinity and water temperature ($P< 0.01$) was noted in the present study in both systems. Salinity showed positive correlation with TSS ($P< 0.01$) in both systems. An inverse relation between DO and CO_2 content was detected in both extensive and modified extensive systems ($P< 0.01$). Positive correlation between alkalinity and pH was observed in extensive and modified extensive systems ($P< 0.05$, $P< 0.01$, respectively). In the present study in both systems, there was negative correlation between total hardness and pH ($P< 0.05$). Results of ANOVA comparing various water quality variables between extensive and modified extensive systems and between seasons yielded highly significant multivariate tests both for systems and seasons.*

INTRODUCTION

For successful shrimp culture operation, good quality of source water is an essential prerequisite (Chanratchakool et al., 1994; Tookwinas, 1998). Excessive fluctuations in abiotic factors like dissolved oxygen, salinity and temperature may increase stress and susceptibility to disease (Kautsky et al., 2000).Though study of water quality of fish and shrimp ponds in India, initiated as early as 1927 by Sewell (1927), was continued by several others, most such studies are on freshwater fish ponds. Similar studies on brackish water counterparts are scarce, especially from Kerala. Moreover, comparative studies on the water quality of different types of shrimp culture systems are also glaringly scant. The present study envisaged assessing the water quality of extensive and modified extensive *Penaeus monodon* culture ponds in Kerala.

MATERIALS AND METHODS

Six culture ponds growing *P. monodon* were selected from Kollam district, Kerala state (9.28'45° N and 76.28'0° E). In two ponds, (0.7 ha each), located at Munrothuruthu, 30 km northwest of Kottiyam town and fed with water from the Ashtamudi lake, extensive type of culture (stocking density = 5 m^{-2}) having neither specific management practices nor supplementary feeding was practiced. In four ponds (0.4 to 0.6 ha each), two located at Mayyanadu about 12 km southwest and two at Pathayakkodi 5 km south of Kottiyam town, all fed with water from the Paravoor Kayal, modified extensive type of farming (stocking density =10 m^{-2}) was done. In these ponds pellet feed was given, thrice a day.

Water samples were collected from all the six ponds during, June 2006-May2007. Water temperature, pH and salinity (‰) were recorded at the site itself using a Celsius thermometer of $\pm$ 0.5oC accuracy, portable pH meter of $\pm$ 0.1 accuracy [Model No. ip (1-198107) RI, USA], and portable refractometer (Erma Inc., Tokyo), respectively. Dissolved oxygen content (DO, mg l^{-1}) was estimated employing the classical Winkler's (1888) method. Dissolved carbondioxide concentration (CO2, mg l^{-1}) was estimated by following the procedure of APHA (1998). Hydrogen sulphide (H_2S, mg l^{-1}), total alkalinity (mg l^{-1}) and total suspended solids (TSS, mg l^{-1}) were estimated by the method of Trivedy et al.(1987), total hardness (mg $^{l-1}$) by the method of Golter-manet al.(1978), ammonia concentration (NH_3, mg l^{-1}) by the method of Koroleff (1983). For spectrophotometric assays, a dual beam spectrophotometer (Model UV2-100, UNICAM, UK) was used.

Statistically significant differences, if any, of water quality parameters between seasons and between systems were determined by two way ANOVA and correlation analysis was done to find out the dependence of water quality variables, both using "statistiXL 1.8" package.

RESULTS AND DISCUSSION

Mean water temperatures in extensive system and modified extensive system registered highest during premonsoon (30.5, 30.9 °C) and lowest during monsoon (28.8, 28.0 °C) (Fig. 1.1). According to Thompson (1991), surface water records high temperature during January-April due to warm weather and high solar radiation compared to other times of the year, which holds good in the present study and agrees with the observations by Islam et al. (2004), Mishra et al. (2008) and Abraham and Sasmal (2009). Between the seasons, the difference in water temperature was significant ($P< 0.05$).

Mean water pH in extensive system during the three seasons was nearly neutral, registering 6.9, 7.1and 7.0, respectively during premonsoon, monsoon and postmon-

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soon, whereas in modified extensive system, it was noticeably alkaline throughout (7.4, 8.0, and 7.6, respectively) (Fig. 1.2). The pH range recorded during the present study is in agreement with the observations of many workers in aquaculture ponds in India (Mishra et al., 2008; Abraham and Sasmal, 2009). The significant positive correlation between pH and DO of extensive system ($P < 0.05$), tallies with the observation by Mollah et al. (1979). Between systems, the difference in pH was statistically significant ($P < 0.01$).

In extensive and modified extensive system, mean salinity recorded the lowest during monsoon (7.0‰, 9.1‰) and the highest during premonsoon (20.3‰, 25.8‰). Lowest salinity during monsoon season (Fig. 1.3) tallies with the observation of Abraham and Sasmal (2009) and was because of heavy rainfall and fresh water inflow into the estuary feeding these ponds (Ramamirtham and Dinesh Babu, 1988). The high salinity registered during premonsoon season agrees with the observations by Islam et al. (2004) and Abraham and Sasmal (2009), and is attributed to low rainfall, reduction in river runoff and dominance of neretic waters. The positive correlation between salinity and water temperature ($P < 0.01$)noted in the present study in both systems tallies with the observation by Ajithkumar et al. (2006). Between the systems and seasons, the difference in salinity was statically significant ($P < 0.01$).

In extensive system, mean DO was lower than in modified extensive system, the seasonal means in the two systems being 3.0, 3.8 and 2.6 mg l^{-1} and 5.9, 4.5 and 5.5 mg l^{-1}, respectively. In modified extensive system, the highest mean DO was observed during premonsoon (Fig. 1.4), which might be due to routine water exchange and aeration (Rajyalakshmi et al., 1988; Chandra Prakash et al., 1997). Between the systems, the difference in DO was significant ($P < 0.01$).

In extensive system, mean dissolved CO_2 ranged from 7.8 mg l^{-1} during monsoon to 11.3 mg l^{-1} during premonsoon. Mean dissolved CO_2 in modified extensive system ranged from 6.8 to 7.9 mg l^{-1} (Fig. 1.5). An inverse relation between DO and CO_2 content was noted in both extensive and modified extensive systems ($P < 0.01$). Similar observations by Geetha Bhadran (1997). The difference in CO_2 between systems ($P < 0.01$) and seasons ($P < 0.05$) was significant.

In extensive and modified extensive systems, dissolved H_2S was very low during all three seasons, registering a seasonal range of 0.04-0.07 mg l^{-1} in the former and 0.02-0.07 mg l^{-1} in the latter (Fig. 1.6). Chen (1985) recommended a safe level of 0.033 mg l^{-1} for *P. monodon*. In modified extensive system, H^2S had significant inverse relation with pH ($P < 0.01$) and direct relation with water temperature and salinity($P < 0.01$). Between the systems and seasons, the difference in H_2S was significant ($P < 0.01$).

In both extensive (seasonal range = 0.14-0.30 mg l^{-1}) and modified extensive systems (seasonal range = 0.15-0.41 mg l^{-1}), NH_3concentration was very low during all three seasons. In both systems, NH_3 was positively correlated with water temperature and salinity. The observed higher NH_3 content in both systems during post- and premonsoons (Fig. 1. 7) agrees with the observations by Mathivanan et al. (2005) in fish ponds in Tamil Nadu. Kumaresan et al. (1997) found lower NH_3 concentration in the initial days of culture, which was true in the present study also. Between systems and seasons, the difference in NH_3 was significant ($P < 0.01$).

In extensive system and modified extensive system, mean alkalinity was the lowest during monsoon (27.4 mg l^{-1}, 45.8 mg l^{-1}) and the highest during premonsoon (46.7 mg l^{-1}, 67.7 mg l^{-1}) (Fig. 1.8). Similar observations have been reported by Chakraborti et al. (1985). Low rainfall coupled with evaporation might have caused increase in alkalinity during premonsoon as reported by Radhika et al. (2004). The positive correlation between alkalinity and pH in extensive ($P < 0.05$) and modified extensive system ($P < 0.01$) noted in the present study agrees with the observations by Ramamirtham and Dinesh Babu (1988). The difference in alkalinity between systems ($P < 0.01$) and seasons ($P < 0.05$) was significant.

In both extensive and modified extensive systems, mean total hardness registered the highest during premonsoon (255.8 mg l^{-1}, 817.5 mg l^{-1}) and the lowest during monsoon (82.6 mg l^{-1}, 100.7 mg l^{-1}) (Fig. 1.9). Islam et al. (2004) recorded the highest hardness during premonsoon in shrimp farms of Sunderban mangrove forest. In the present study in both extensive and modified extensive systems, there was negative correlation between total hardness and pH ($P < 0.05$)as also noted by Chanratchakool et al. (1994). Between systems and seasons, the difference in hardness was significant ($P < 0.01$).

Inextensive system, mean TSS registered the lowest (4,225 mg l- 1) during monsoon and the highest during premonsoon (17,525 mg l-1). The corresponding values for modified extensive system were 3,124 mg l-1 and 19,113 mg l-1. The highest TSS registered during premonsoon in both systems, tallies with the observations by Venkatesan et al. (2001). Comparatively high levels of TSS observed in modified extensive system may be due to presence of unutilized feed particles and excreta of organisms (Kaladharan et al., 1999). Seasonal difference in TSS within the two systems was significant ($P < 0.01$).

CONCLUSIONS

In many water quality parameters, extensive and modified extensive systems differed significantly, particularly in regard to such important parameters as pH, salinity, DO, CO_2, H_2S, NH_3, alkalinity and hardness. Results of ANOVA comparing various water quality variables between extensive and modified extensive systems and between seasons yielded highly significant multivariate tests both for systems and seasons. Notwithstanding these differences, all water quality parameters estimated of the two systems fell well within the ranges reported from various brackishwater bodies on the southwest coast of India and were found to be conducive for shrimp culture. Modified extensive farming, which adopts stocking disinfected PL, measures for avoiding cross contamination and use of probiotics, maintaining favourable water quality have slight edge over extensive type of farming.

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Table 1 Mean atmospheric temperature and hydrographical parameters of extensive and modified extensive shrimp culture systems during three seasons of shrimp culture operation.

Parameters	Extensive System				Modified Extensive System					
	Pre-monsoon	Monsoon	Post-monsoon	Mean	Pre-monsoon	Monsoon	Post-monsoon	Mean		
Water Temp. (^{0}C)	30.5	28.8	29.5	29.5	30.9	28	29.6	29.4		
pH	6.9	7.1	7.0	7.0	7.4	8.0	7.6	7.7		
Salinity (‰)	20.3	7.0	18.8	14.5	25.8	9.1	22.6	18.2		
DO (mg ℓ^{-1})	3.0	3.8	2.6	3.2	5.9	4.5	5.5	5.2		
CO_2 (mg ℓ^{-1})	11.3	7.8	10	9.5	7.9	7.6	6.8	7.4		
H_2S (mg ℓ^{-1})	0.07	0.04	0.07	0.06	0.06	0.02	0.07	0.05		
NH_3 (mg ℓ-1)	0.22	0.14	0.3	0.21	0.41	0.15	0.31	0.28		
Total alkalinity (mg ℓ^{-1})	46.7	27.4	42.7	37.8	67.7	45.8	56	55.4		
Total hardness (mg ℓ^{-1})	255.8	82.6	208.3	172.3	817.5	100.7	634.2	475.8		
TSS (mg ℓ^{-1})	17525	4225	8383	9463	19113	3124	7917	9359		

Table 2. Results of correlation analysis showing r values comparing various water quality parameters of extensive (N = 40) and modified extensive (N=80) shrimp culture system

Extensive system									
Parameters	Temp_W	pH	Sal..	DO	CO_2	H_2S	NH_3	Alk.	Har_T
pH	-0.098								
Sal.	0.458#	-0.232							
DO	-0.612 #	0.332*	-0.591#						
CO_2	0.533#	-0.163	0.557#	-0.715#					
H_2S	0.155	0.135	0.606#	-0.123	0.324				
NH_3	0.388*	0.049	0.526#	-0.692#	0.522#	0.363*			
Alk.	0.377*	0.382*	0.358	-0.15	0.387	0.453#	0.410#		
Har_T	0.227	-0.370*	0.725#	-0.318*	0.395	0.460#	0.198	0.149	
TSS	0.237	-0.071	0.539#	-0.21	0.375	0.576#	0.271	0.468#	0.473#
Modified extensive system									
Parameters	Temp_W	pH	Sal.	DO	CO_2	H_2S	NH_3	Alk.	Har_T
pH	0.088								
Sal.	0.560#	-0.225*							
DO	0.071	-0.318#	0.363#						
CO_2	0.129	0.133	-0.061	-0.651#					
H_2S	0.412#	-0.367#	0.687#	0.206*	0.007				
NH_3	0.487#	0.064	0.668#	-0.017	0.249*	0.453#			
Alk.	0.415#	0.456#	0.419#	0.218*	0.011	0.233*	0.463#		
Har_T	0.438#	-0.230*	0.866#	0.368#	-0.068	0.621#	0.708#	0.421#	
TSS	0.577#	-0.152	0.676#	0.174	0.092	0.391#	0.696#	0.431#	0.775#
(Alk., alkalinity; Har_T, total hardness; Sal., salinity; Temp_W, water temperature)									

*P < 0.05; # P < 0.01

Table 3.Results of ANOVA comparing water quality variables between extensive andmodified extensive systems and between seasons and showing system*season interaction

	Source	Type III SS	Df	MS	F	
Temp_W	Total	494.367	119			
	System	0.001	1	0.001	0.000	
	Season	37.806	2	18.903	4.733	*
	System*Season	1.239	2	0.619	0.155	
	Error	455.333	114	3.994		
pH	Total	59.287	119			
	System	11.192	1	11.192	28.494	#
	Season	1.850	2	0.925	2.355	
	System*Season	0.194	2	0.097	0.246	
	Error	44.778	114	0.393		
Sal.	Total	8621.148	119			
	System	425.114	1	425.114	10.845	#
	Season	3414.859	2	1707.429	43.558	#
	System*Season	69.090	2	34.545	0.881	
	Error	4468.643	114	39.199		
DO	Total	485.252	119			
	System	125.205	1	125.205	40.456	#
	Season	1.127	2	0.563	0.182	
	System*Season	16.415	2	8.207	2.652	
	Error	352.811	114	3.095		
CO_2	Total	984.766	119			
	System	128.349	1	128.349	18.854	#
	Season	56.079	2	28.040	4.119	*
	System*Season	70.597	2	35.298	5.185	#
	Error	776.044	114	6.807		
H_2S	Total	0.066	119			
	System	0.002	1	0.002	5.993	#
	Season	0.015	2	0.008	19.252	#
	System*Season	0.002	2	0.001	1.952	
	Error	0.046	114	0.000		
NH_3	Total	3.020	119			
	System	0.142	1	0.142	7.032	#
	Season	0.499	2	0.249	12.358	#
	System*Season	0.008	2	0.004	0.189	
	Error	2.300	114	0.020		
Alk.	Total	71456.425	119			
	System	8105.921	1	8105.921	15.759	#
	Season	3836.253	2	1918.127	3.729	*
	System*Season	720.773	2	360.386	0.701	
	Error	58636.190	114	514.353		
Har_T	Total	12350093.592	119			
	System	2975281.375	1	2975281.375	59.669	#
	Season	2226317.118	2	1113158.559	22.324	#
	System*Season	574951.407	2	287475.703	5.765	
	Error	5684404.917	114	49863.201		
TSS	Total	6051733596.667	119			
	System	1306703.157	1	1306703.157	0.040	
	Season	2195171427.500	2	1097585713.750	33.332	#
	System*Season	156608983.056	2	78304491.528	2.378	
	Error	3753886737.500	114	32928831.031		

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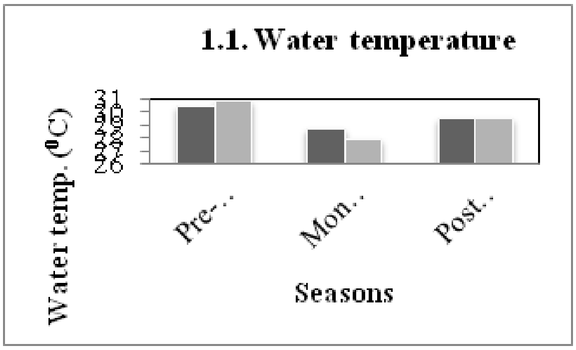
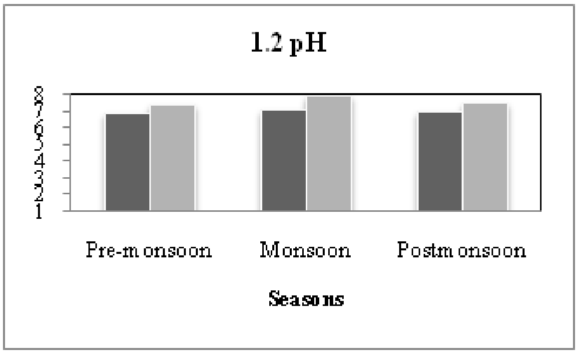
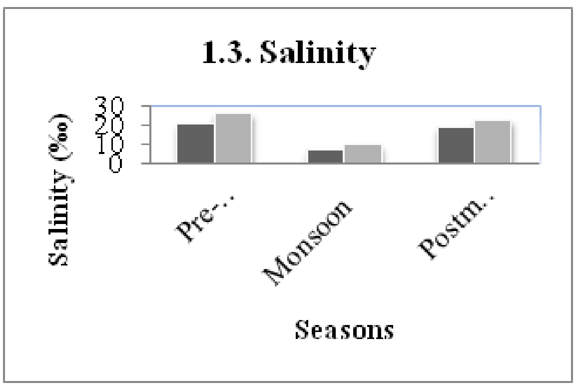
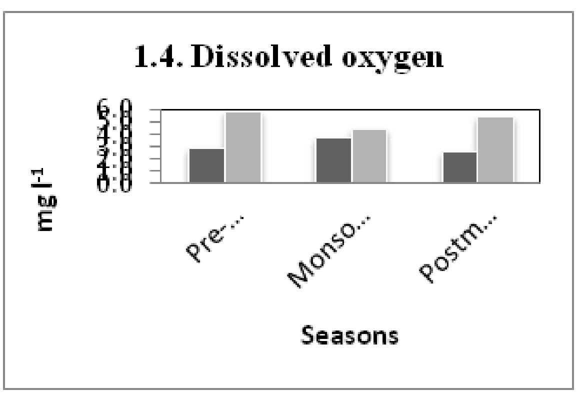
(Alk., alkalinity; Har_T, total hardness; Sal., salinity; Temp_W, water temperature)

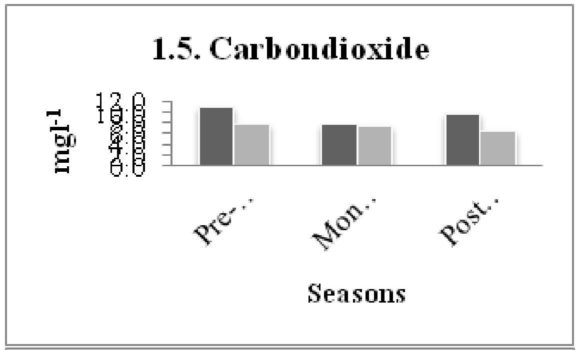
*P < 0.05; # P < 0.01

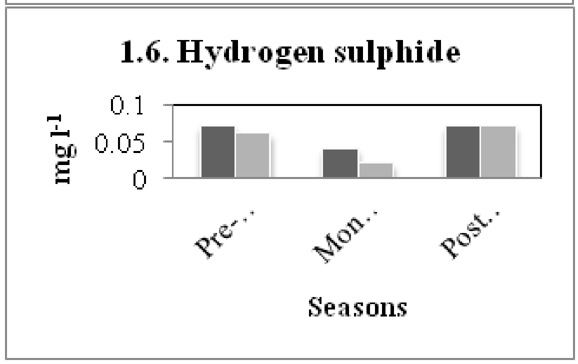


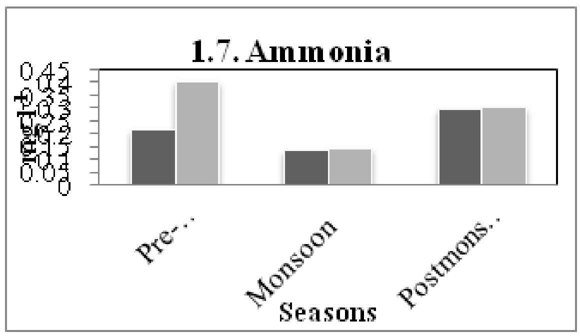


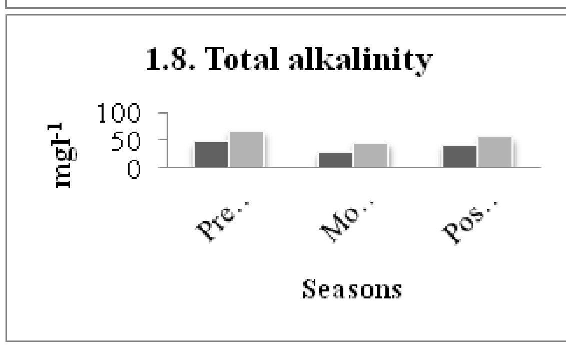












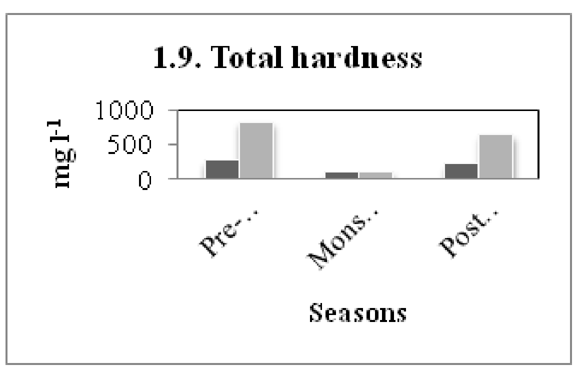


Fig. 1. Seasonal variation in water quality parameters of extensive ( ) and modified extensive ( ) *Penaeus monodon* culture systems.

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