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Multiple correlation of water quality parameters in different culture ponds of whiteleg shrimp (*Litopenaeus vannamei*, Boone, 1931)

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ABSTRACT

Aim: The aim of the study was to assess the important physico-chemical parameters (salinity, temperature, transparency, pH, dissolve oxygen, total hardness, calcium hardness, magnesium hardness, total alkalinity, ammonia, nitrate-N and nitrite-N) in the earthen and PEL culture ponds of Sea Aquafarm, Surat (Gujarat) and to develop the appropriate management strategies correlation were also carried out among the studied parameters.

Materials and Methods: The study the water samples were collected during summer crop(March to June 2021) from earthen and polyethene lined ponds of shrimp farm, Sea Aquafarm, Surat (Gujarat). The water samples were collected in pre-rinsed and tagged wide mouthed polythene bottles and water quality parameters were analysed *in-situ* and for remaining parameters.

Results: The results showed that salinity (26.250±1.077 ‰), temperature (27.925±0.733 °c), transparency (33.125±9.544 cm), ph (8.125±0.123), dissolve oxygen (6.875±0.334 mg/l), total hardness (4462.500±119.791 mg/l), ch (340.680±22.494 mg/l), mh (881.280±38.705 mg/l), total alkalinity (245.000±11.979 mg/l), ammonia-n (0.267±0.191 mg/l), nitrate-n (9.447±2.605 mg/l) and nitrite-n (0.162±0.062 mg/l) in earthen pond and salinity (25.750±0.819 ‰), temperature (28.900±0.725 °c), transparency (44.750±2.407 cm), ph (7.932±0.124), dissolve oxygen (6.175±0.302 mg/l), total hardness (4650.000±154.110 mg/l), ch (330.660±5.010 mg/l), mh (933.135±36.215 mg/l), total alkalinity (301.250±11.232 mg/l), ammonia-n (0.455±0.218 mg/l), nitrate-n (12.245±2.591 mg/l) and nitrite-n (0.225±0.064 mg/l) in PEL pond.

Conclusion: It was concluded that the water quality parameters in both the ponds were non-significantly different and the similar pattern among these parameters were also quantify by correlation.

Keywords: Correlation matrix, earthen pond, PE lining pond, whiteleg shrimp, cultureponds, Water quality

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Introduction

Water is one of creative elements on the earth and its blessed elixir to keep life vibrant. On the basis of their physical and chemical quality it is categorized in three different categories i.e., fresh, brackish and marine. As known that brackish and marine water are available in huge amount (97% of total water) on earth (Beth et al., 2016). Although it is not safe for human consumption directly but it plays very important role in human life by providing food and livelihoodin terms of seafood particularfish and shellfish (shrimps) and its farming activityrespectively. Whiteleg shrimp *L. vannamei* is the exotic species of shrimp majorly stock in Indian brackish water from 2009 to till because in *P. monodon* culture WSSV disease outbreak and farmers faced huge lose (Prajapati and Ujjania, 2022). Nevertheless, shrimp (*L. vannamei*) demand is increases and to fulfill demand necessity to acceleration in productions and yield of cultured shrimp. The implementation of innovations in aquaculture plays important role to enhance production likewise use of polyethylene liners in earthen pond.

The water quality is a very important natural indicator for vital condition, competent and growth with superior production of aquatic organism including shrimp (Boyd, 1990). It is also an important tool for evaluating the feasibility of aquatic environment for shrimp farming culture (Ma et al., 2013; Ariadi et al., 2019). Moreover, quality of water is directly related to the health of the water body (Shinde et al., 2011). The water quality of culture pond help to increasing productivity and it provide nutritionally balanced and healthy environment to cultured animals including shrimp (Venkateswarlu et al., 2019) has a significant role in increasing the total production of the pond (Kahar, 2024). The water quality parameters and their impact on aquatic inhabited species (Prajapati and Ujjania, 2021; Ghosh and Maity, 2024; Shah et al., 2024).

Correlation analysis in between or among variables (water quality parameters) is descriptive technique to estimate the degree of linear association in between or among parameters. Therefore, to identify most significant parameter of water quality and its correlation with other parameters, correlation matrix study is widely used (Vinay et al., 2025). Correspondingly, it is also used to develop mathematical relationship for comparison of physico-chemical parameters (Bhandari and Nayal, 2008). The study on water quality of earthen pond and PELP is an important aspect. Henceforth, in the present study analysis, correlation and comparisons of the water quality parameters were conducted in different shrimp (*Litopenaeus vannamei*, Boone, 1931) culture ponds to justify the use of pond system and the finding of the investigation would be important to develop the pond management strategies

Materials and Methods

To analysed interrelationship between water parameter, the water samples were collected during summer crop (March to June 2021) from earthen and polyethene lined ponds of shrimp farm, Sea Aquafarm, Surat (Gujarat). The water samples were collected in pre-rinsed and tagged wide mouthed polythene bottles and water quality parameters including temperature, transparency, dissolved oxygen and salinity were analysed *in-situ* and for remaining parameters pH, total alkalinity, total hardness, ammonia (NH_3-N), nitrite (NO_2-N) and nitrate (NO_3-N) water sample bottles were transferred to the Research Laboratory, Department of Aquatic Biology (VNSGU, Surat). These all water quality parameters were analysed to follow the standard methods of Trivedi and Goel (1986) and APHA (2005). The statistical analysis i.e. t-test and correlation coefficient (r) of the water quality variables were calculated by statistical software SPSS (v26).

Results and Discussion

Salinity is enormously concentration of dissolved salts and vital to sustain the shrimp in wter resources. The fluctuations in salinity affects the other water quality parameters lie dissolved oxygen alkalinity which is not favorable for the growth of shrimp (Atwood et al., 2003). In present study, the salinity was noted 26.250±1.077 ppt in earthen pond and 25.750±0.819 ppt in PE lined pond (Table 1) which was very close of within the optimum range (15 to 25 ppt) reported by Bett and Vinatea (2009). Temperature affects the physiological and biological processes of the aquatic organism as well as aquatic environment (Boyd, 1990; Arrignon et al., 1994). The changesin pond water temperature influences the metabolism (Allan et al., 2006), growth and survival (Guan et al., 2003), molting cycle (Guan et al., 2003) and immune response of the crustacean (Cheng et al., 2005). The pond water temperature 27.925±0.733 °C and 28.900±0.725 °C was noted in EP and PELP respectively (Table 1) which wassuitable for optimal growth of shrimp (Bett and Vinatea, 2009). Transparency referred as dispersion of light through water surface and it play key role in survival and growth during initial of stocking toentire culture cycle of shrimp (Boyd, 1990). It is measure the presence of suspended particles and it was noted 33.125±9.544 cm in EP and 44.750±2.407 cm in PELP that is suitable for optimal growth of shrimp species (Boyd, 1990).

The potential of hydrogen (pH) is one of the important parameter for the growth of shrimp and affect ability to maintain the salt balance.It was 8.125±0.123 in EP and 7.932±0.124 in PELP during the present study (Table 1). The extreme low or high pH resulted in stresses, soft shell and poor survival of the shrimp (Boyd, 1990). The optimal value of pH (7.5–8.5) for shrimp culture is reported by Reddy and Mounika (2018) which is evident of findings of present study. Dissolved oxygen denotes as concentration of oxygen fused in water that is required for respiration of shrimp (Boyd, 1990; Arrignon et al., 1994). The concentrations of DO near saturation level > 5.0 ppm is healthiest for the growth of shrimp (Cheng et al., 2003) while growth restriction and mortality occurs at below 2.0 ppm of DO (Páez-Osuna, 2001). The DO in present study was 6.875±0.334 mg/l and 6.175±0.302 mg/l in EP and PELP respectively (Table 1). Total hardness is the concentration of total calcium and magnesium ions in water. Total hardness affects the growth of shrimp through its chemical interactions in water while calcium hardness and magnesium hardness affects the shrimp shell and muscles formation (Boyd, 1990). In present study, the total hardness, calcium hardness and magnesium hardness were 4462.500±119.791 mg/l, 340.680±22.494 mg/l and 881.280±38.705 mg/l respectively in EP and 4650.000±154.110 mg/l, 330.660±5.010 mg/l and 933.135±36.215 mg/l respectively in PELP (Table 1). Total alkalinity is the concentration alkaline substances dissolved in the water that can attract and release hydrogen ions. It affects daily variation of pH, molting and growth of shrimp in the pond. Alkalinity concentrations should not exceed 140 mg/l (Ferreira et al., 2011) whereas, optimum alkalinity for shrimp (*L. vannamei*) culture was reported > 120 mg/l by Venkateswarlu et al. (2019). The alkalinity in present study was noticed 245.000±11.979 mg/l in EP and 301.250±11.232 mg/l in PELP (Table 1) that was maintained the optimum ranges with slight variations.

Ammonia-N is the initial product of nitrification and end product of protein catabolism in crustaceans which affects the oxygen consumption and blood pH of shrimp (Arrignon, 1994). It increases tissue oxygen consumption, damages gill, affects growth, molt, and reduces the ability of blood to transport oxygen (Chen and Kou, 1992; Mohanty et. al., 2018). NH_3< 1.0 ppm is suitable for optimal growth of shrimp (Boyd, 1990). The ammonia-N was 0.267±0.191 mg/l and 0.455±0.218 mg/l was observed in EP and PELP respectively (Table 1) which was within the favorable range for whileleg shrimp (Venkateswarlu et al., 2019). Nitrate-N is the dissolved nitrogen form the naturally process in water and high concentration of it could be harmful which affect the osmoregulation of shrimp (Lawson and Thomson, 1995). In present study, the concentration of nitrate-N was 9.447±2.605 mg/l in EP and 12.245±2.591 mg/l in PELP (Table 1). The mean value of nitrate was observed comparatively higher and similar finding Do et al. (2025). Nitrite-N was formed by the nitrification process and was intermediate creation of oxidation of ammonia to nitrate. The high concentrations of nitrite-N deactivate hemocyanin resulted as hypoxia that referred as brown blood disease in shrimp (Boyd and Tucker, 1998). Significant concentrations of nitrite-N accumulate in culture pond decrease the immune ability of *L. vannamei* that increase the susceptibility and vibrios infection (Tseng and Chen, 2004). The mean value of nitrite-N 0.162±0.062 mg/L and 0.225±0.064 mg/l was recorded in EP and PELP respectively (Table 1). The findings reported by Warisara (2000) in two shrimp ponds in Thailand was quite similar to thefin dings of present study similarly, Chien (1992) and Venkateswarlu et al. (2019) were also reported favorable value of Nitrite-N for shrimp was < 0.5 mg/l.

The observations showed that observed water quality parameters in studied ponds were at the optimum level and suitable for shrimp culture. It was described (Table 1) that variations in the water quality parameters of EP and PELP was non-significant (p > 0.01).

The application of correlation module is the preliminary descriptive technique to estimate the degree of association and dependency ofthe variables which was sybolized by the correlation coefficient (r). The value of coefficient 'r' range -1 to +1 specifies positive and negative linear correlation respectively among the compared two parameters (Kothari et al., 2021). Correlation coefficient (r) value shows that salinity of earthen ponds was positively correlated with temperature (0.856) and negatively related with transparency (-0.930) while it was positive correlated with total hardness (0.990) and negative correlated with pH (-0.880) in polyethylene lined pond. Temperature in EP was directly related to the total alkalinity (0.997) and inversely related to the dissolve oxygen (-0.985) whereas, in PELP it was directly related to the ammonia-N (0.945) and inversely related to the pH (-0.976). Transparency with dissolve oxygen show positive correlation (0.881) and with salinity it was negative correlation (-0.930) in EP. Whereas, it was positively proposenet with calcium hardness (0.571) negative with ammonia-N (-0.565) in PELP. Positive correlation (0.563) between pH and ammonia and it was negative (-0.815) between pH and magnesium hardness in EP. Whereas, in PELP the pH and dissolve oxygen was positively (0.665) related and pH and temperature show negative correlation (-0.976).

The correlation coefficient "r" value 0.881 shows that dissolve oxygen and transparency was positively correlated and -0.994 showed dissolvely oxygen was negative correlated with

Table 1. Water quality parameters and statistical test for the parameters of EP and PELP culture ponds

Parameter	Unit	Earthen pond	Polyethelene lined pond	t	df	Sig.
		Mean ± SE	Mean ± SE			
Salinity	(‰)	26.250±1.077	25.750±0.819	0.343	5.856	0.744
Temperature	(°C)	27.925±0.733	28.900±0.725	-0.839	5.991	0.434
Transparency	(cm)	33.125±9.544	44.750±2.407	-1.000	3.363	0.384
pH	-	8.125±0.123	7.932±0.124	0.999	5.922	0.357
Dissolve Oxygen	(mg/l)	6.875±0.334	6.175±0.302	1.328	5.915	0.233
Total Hardness	(mg/l)	4462.500±119.791	4650.000±154.110	-0.830	5.668	0.440
Calcium hardness	(mg/l)	340.680±22.494	330.660±5.010	0.361	3.272	0.740
Magnesium hardness	(mg/l)	881.280±38.705	933.135±36.215	-0.868	5.998	0.419
Total Alkalinity	(mg/l)	245.000±11.979	301.250±11.232	-3.018	5.994	0.230
Ammonia-N	(mg/l)	0.267±0.191	0.455±0.218	-0.540	5.978	0.609
Nitrate-N	(mg/l)	9.447±2.605	12.245±2.591	-0.646	5.988	0.542
Nitrite-N	(mg/l)	0.162±0.062	0.225±0.064	-0.587	5.999	0.579

Note: Sig. is the significance (0.01%), t is calculated value, df is degree of freedom and SE is standard error

Table 2. Correlation matrix of physicochemical parameters of EP and PELP culture ponds

Parameter	Pond	Salinity	Temp.	Transp.	pH	DO	TH	CH	MH	TA	Ammo.	Nitrate	Nitrite
Salinity	EP	1.000											
	PELP	1.000											
Temp.	EP	0.856	1.000										
	PELP	0.778	1.000										
Transp.	EP	-0.930	-0.928	1.000									
	PELP	-0.040	-0.655	1.000									
pH	EP	-0.038	-0.215	0.374	1.000								
	PELP	-0.880	-0.976*	0.507	1.000								
DO	EP	-0.757	-0.985	0.881	0.294	1.000							
	PELP	-0.812	-0.646	-0.011	0.665	1.000							
TH	EP	0.453	0.293	-0.606	-0.768	-0.256	1.000						
	PELP	0.990*	0.827	-0.118	-0.902	-0.870	1.000						
CH	EP	0.666	0.711	-0.504	0.528	-0.655	-0.354	1.000					
	PELP	0.457	0.034	0.571	-0.090	-0.784	0.487	1.000					
MH	EP	0.102	-0.042	-0.286	-0.815	0.050	0.932	-0.669	1.000				
	PELP	0.989*	0.856	-0.171	-0.929	-0.838	0.997**	0.421	1.000				
TA	EP	0.814	0.997	-0.900	-0.219	-0.994	0.246	0.713	-0.080	1.000			
	PELP	0.857	0.418	0.396	-0.537	-0.880	0.848	0.835	0.811	1.000			
Ammo.	EP	0.550	0.653	-0.401	0.563	-0.617	-0.476	0.988	-0.761	0.666	1.000		
	PELP	0.750	0.945	-0.565	-0.894	-0.812	0.832	0.285	0.839	0.523	1.000		
Nitrate	EP	0.674	0.812	-0.588	0.359	-0.785	-0.287	0.977	-0.606	0.823	0.972	1.000	
	PELP	0.771	0.917	-0.489	-0.873	-0.863	0.852	0.376	0.853	0.589	0.995**	1.000	
Nitrite	EP	0.653	0.854	-0.621	0.239	-0.848	-0.243	0.936	-0.555	0.872	0.937	0.989	1.000
	PELP	0.888	0.902	-0.334	-0.905	-0.912	0.944	0.463	0.941	0.731	0.962*	0.976*	1.000

-1.0	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	+0.1	+0.2	+0.3	+0.4	+0.5	+0.6	+0.7	+0.8	+0.9	+1.0

Note: EP for earthen pond, PELP for polyethylene lined pond, Temp.for temperature, Transp. for transparency, DO for dissolve oxygen, TH for total hardness, CH for calcium hardness, MH for magnesium hardness, TA for total alkalinity, Ammo. For Ammonia-N, Nitrate for Nitrate-N and Nitrite for Nitrite-N for, *0.05 significant level, **0.01 significant level

total alkalinity in EP, moreover, in PELP it was directly proposenet with pH (0.665) and inversely proposenet with nitrite-N (-0.912). The total hardness showed positive correlation 0.932 and 0.997 with magnesium hardness and negative correlation -0.768 and -0.902 with pH in EP and PELP respectively. Calcium hardness and ammonia showed positive correlation (0.988) while calcium hardness and magnesium hardness showed negative correlation (-0.669) in EP. It was positive with total alkalinity (0.835) and with negative with dissolve oxygen (-0.784) in PELP. The magnesium hardness was positively correlated with total hardness (0.932 and 0.997) and negative correlated with pH (-0.815 and -0.929) in EP and PELP it respectively. The total alkalinity and temperature was positive correlation (0.997) and it was negative with dissolve oxygen (-0.994) in EP. While in PELP, total alkalinity was directly proposenet (0.848) to total hardness and inversely proposenet (-0.880) to dissolve oxygen in PELP.

The ammonia-N showed positive (0.988) and negative (-0.761) relationship with calcium hardness and magnesium hardness respectively in EP while in PELP it was positive (0.995) and negative (-0.894) relationship with nitrate-N and pH respectively. Nitrite-N and nitrate-N shows positive (0.898) while nitrate-N and dissolve oxygen shows negative (-0.785) correlation in EP whereas it was positive correlated with ammonia-N (0.995) and with pH (-0.873) in PELP. The findings depicted that in EP nitrate-N was positive correlated (0.989) with nitrite-N and negative correlated (-0.848) with dissolve oxygen while it was positive correlation (0.976) with nitrite-N and negative correlation (-0.912) with dissolve oxygen in PELP. The findings on correlation described (Table 2) are corroborated with the findings of findings of Zafar et al. (2015), Ariadi et al. (2019), Kahar (2024) and Vinay et al. (2025) and validate the application of present study.

Conclusions

It was concluded that water quality parameters in both the ponds were non-significantly different and the similar pattern among these parameters were also quantify by correlation. It shows that pond management practices followed by the farmers were at optimum level in both pond system. Furthermore, the linear correlation is very useful to get fairly accurate idea of the water quality of culture pond and predicting the quality condition.

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