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Research article

Quantitative analysis of water quality parameters and their influence on the Pacific white shrimp (*Litopenaeus vannamei*) culture: A case study of Rancong mariculture area in Lhokseumawe, Aceh, Indonesia

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Abstract

Water quality is one of several aspects that affect the success of aquaculture business. This study analyzes water quality and assesses its impact on aquaculture enterprises in the Rancong pond region of Lhokseumawe City. The study ran from November to December 2018. The water quality of the Rancong pond was sampled directly and tested in multiple labs. The field survey and purposive sampling strategy separated the research location into four stations with three water sampling points. Temperature, salinity, turbidity, brightness, pH, dissolved oxygen, alkalinity, total organic matter, BOD5, total ammonia nitrogen, nitrite, nitrate, phosphate, lead (Pb), total Vibrio bacteria, total general bacteria, and phytoplankton types and abundance were measured. The suitability of water quality is assessed using descriptive analysis, scoring, and matching. The investigation indicates that the quality and maintenance of the source water are highly suitable (S1). Traditional vannamei shrimp ponds in Rancong, Lhokseumawe City, should be maintained as fisheries cultivation areas.

Keywords: Physicochemical water parameter, feasibility study, aquaculture area, prawn

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Introduction

Lhokseumawe is a city that focuses primarily on economic development in the fishery cultivation sector, particularly in grow-out operations. The city is in a coastal area, with a significant amount of land dedicated to this purpose (Aprilla et al., 2023). Aquaculture is the practice of cultivating aquatic organisms by carefully managing their environment to mimic their native habitat. The primary objective of this endeavour is to generate financial gain while also meeting the nutritional needs of the local population. Water quality conditions could have a significant influence on the success of aquaculture operations (Boyd & Tucker, 2012). Water quality refers to the degree to which water is suitable for the survival and development of aquatic organisms and is assessed based on specific criteria known as quality standards (Muti'ah et al., 2022). High water quality, according to established criteria, promotes optimal growth and maintains the health of organisms, resulting in a high survival rate at the end of the maintenance period. Every planter wants to attain these objectives to succeed in the fishing cultivation activity (Hasan et al., 2021).

The Rancong Pond area, located in East Batuphat Village, Lhokseumawe City, has been traditionally managed by the local community as a means of livelihood since the 1970s. The predominant biota now under cultivation is vannamei shrimp (*Litopenaeus vannamei*). Culturing Vannamei shrimp in this location is economically significant because of its higher resistance to disease attacks. However, the actual output of the production process remains somewhat limited, and it is not unusual for failures to occur throughout production (Amiin et al., 2023). There is a growing recognition of the need to ensure the sustainability of the vannamei shrimp cultivation business in the Rancong pond area. As a result, research is required on the feasibility of studying water quality in traditional vannamei shrimp ponds in the Rancong pond area, Lhokseumawe City, to verify the condition and suitability of the source water quality and the management of the pond.

Methods

This research was carried out from November to December 2018. The water quality parameters were measured directly (in situ) in the Rancong Farming Area, Lhokseumawe City and analyzed in several laboratories (ex situ), namely the Laboratory of Water Quality and Fish Nutrition, Universitas Malikussaleh, Laboratory of PT. CP Prima Bireuen and the Medan Industrial Research and Standardization Laboratory.

The tools used during the research were a 600 ml water sample bottle, a 5 ml phytoplankton sample bottle, a 5-liter bucket, GPS, thermometer, rope, refractometer, Secchi disk, turbidimeter, DO meter, multi-tester, spectrophotometer, cuvette, Erlenmeyer, suction ball, pipette volumetric, measuring pipette, dropper, burette, measuring cup, measuring flask, timer, hot plate with a stirrer, funnel, autoclave, incubator, petri dish, oven, micropipette, spirit lamp, triangle spreader, vortex, colony counter, micro tube, tip, microscope, cover glass, filter paper, test tube, atomic absorption spectrophotometer (AAS), hemocytometer, and plankton net. Meanwhile, the materials used during the investigation were sample water, distilled water, MR-BCG indicator 0.12%, phenolphthalein indicator 0.5%, H_2SO_4 0.02 N, sulfanilamide 1%, NED 0.1%, phenol 10%, sodium nitroprusside 0 .5%, alkaline citrate, sodium hypochlorite technical, H_2SO_4 6 N, oxalic acid 0.01 N, KMnO4 0.01 N, potassium antimonyl, ammonium molybdate 4%, H2SO4 5 N, ascorbic acid 0.1 N, hydrazine sulfate, copper sulfate (CuSO4), cyclohexylamino propane sulphonic acid, acetone, nitric acid (HNO_3), standard solution of lead metal (Pb), ethylene gas (C_2H_2), TSA (tryptic soy agar), TCBS (thiosulfate citrate bile salt sucrose), physiological NaCl 0.85%, and 96% alcohol.

The research employed a field survey method that uses a purposive sampling strategy to determine the sampling points. Data on value and concentration of each water quality parameter evaluated were collected by conducting water sampling activities at four sites. Each station was sampled three times in repetition. The selection of the study station was based on a careful evaluation of the operational ponds in the Rancong pond area, specifically in East Batuphat Village. The descriptions of the four research stations are as follows: Station 1 is located on the first ponds on the eastern side of Rancong street at coordinates N 05013'29.6" and E 097003'24.9". Station 2 is located in the first ponds in the left side of Rancong street at coordinates N 05013'37.6" and E 097003'24.0". Station 3 is located on the second pond on the right side of the right side of Rancong street (N 05013'48" and E 097003'31.9"), and Station 4 is a sampling point in the area that is the source of water intake and discharge in pond culture activities (N 05013'52.7" and E 097003'28.5"). The sampling location showed in Figure 1.

The water quality parameters that are analyzed include physical parameters such as temperature, turbidity, and brightness. Chemical parameters such as pH, salinity, dissolved oxygen, alkalinity, total organic matter, BOD5, total ammonia nitrogen (TAN), nitrite, nitrate, phosphate, and heavy metal lead are also analyzed. In addition, biological parameters such as total Vibrio bacteria, total general bacteria, and the type and abundance of phytoplankton are examined. The measurements of water quality parameters are classified depending on the location and frequency of measurement, considering the observed variations in the parameters' characteristics. Water samples are collected in the morning, specifically from 08.00 to 10.00 WIB. Temperature, salinity, pH, and dissolved oxygen were also assessed during the afternoon from 16:00 to 17:00 WIB. Water samples for analyzing water quality parameters are collected at 10 - 20 cm depth from the water bottom in each replication. Water samples for phytoplankton observations were collected using a 15-liter bucket with a maximum capacity of 5 liters. Subsequently, the collected samples were filtered using a plankton net. The phytoplankton samples will be filtered and collected in a bucket. The contents of the bucket will then be transferred to a 5 ml sample vial bottle designed explicitly for phytoplankton and will be appropriately labelled.

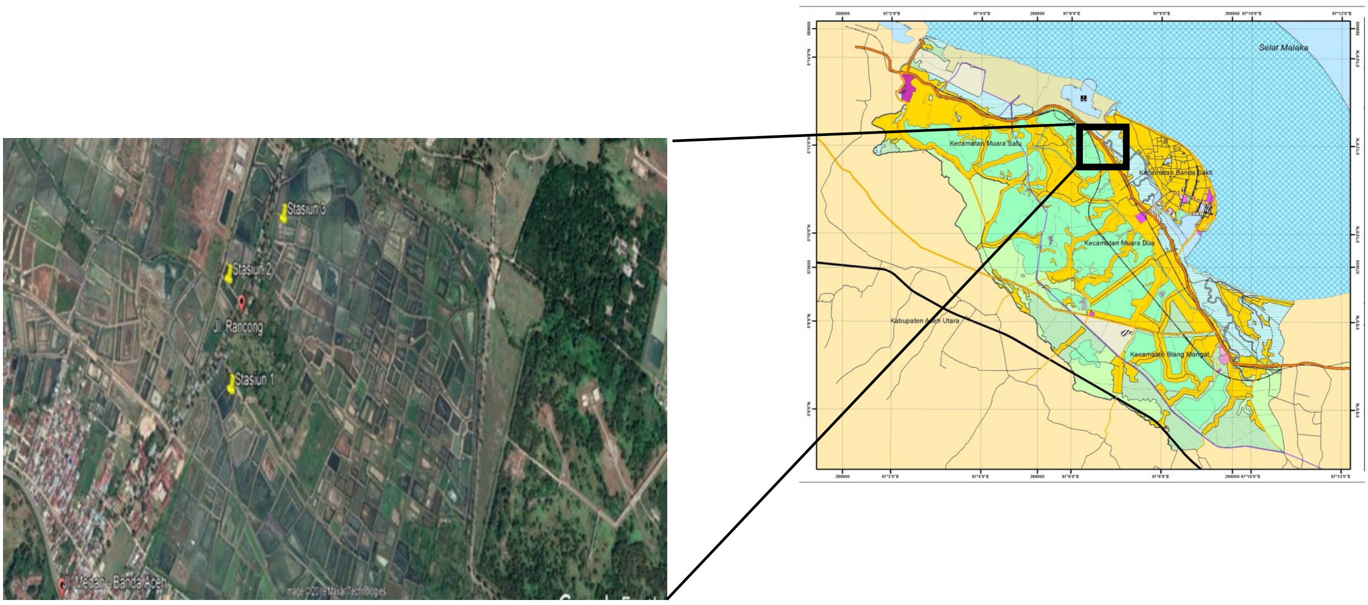

Figure 1. Sampling location

Data analysis

The number of phytoplankton found was calculated by the number of cells per liter using a hemocytometer, relative abundance (KR) and frequency of attendance (FK) (LeGresley, M., & McDermott, G.,2010). In addition, the Shannon-Wienner formula is employed to analyze and quantify the diversity of different forms of aquatic biota; the uniformity index (E) and dominance index (C). Moreover, scoring, or categoric index, where variables with a stronger influence on water quality for use in assessing or determining the suitability of waters for cultivated biota are given a higher score, and variables with a weaker influence are given a lower score. After measuring water potential, the matching approach compares a location's water quality attributes with aquaculture suitability requirements.

The qualitative and quantitative assessment systems to determine the suitability of water quality for the cultivation activities of vannamei shrimp can be seen in Table 1. The total score from the multiplication of parameter values with their weights is used to determine the water quality category by using the formula from Aryawati & Diansyah (2014). The meaning of each level of pond water quality suitability can be seen in Table 2.

Result

Physical parameter

The physical quality of water sampled from each observation station can be seen in Figure 2.

Table 2. Pond water quality eligibility class category.

Total score	Eligibility level	Pond water quality
> 80	Very suitable (S1)	Potential, has no inhibiting factors
60 – 79	Suitable (S2)	Meet minimum requirements
40 – 59	Conditionally appropriate (S3)	Has limiting factors, requires additional input
< 40	Not suitable (TS)	There are very serious limiting factors

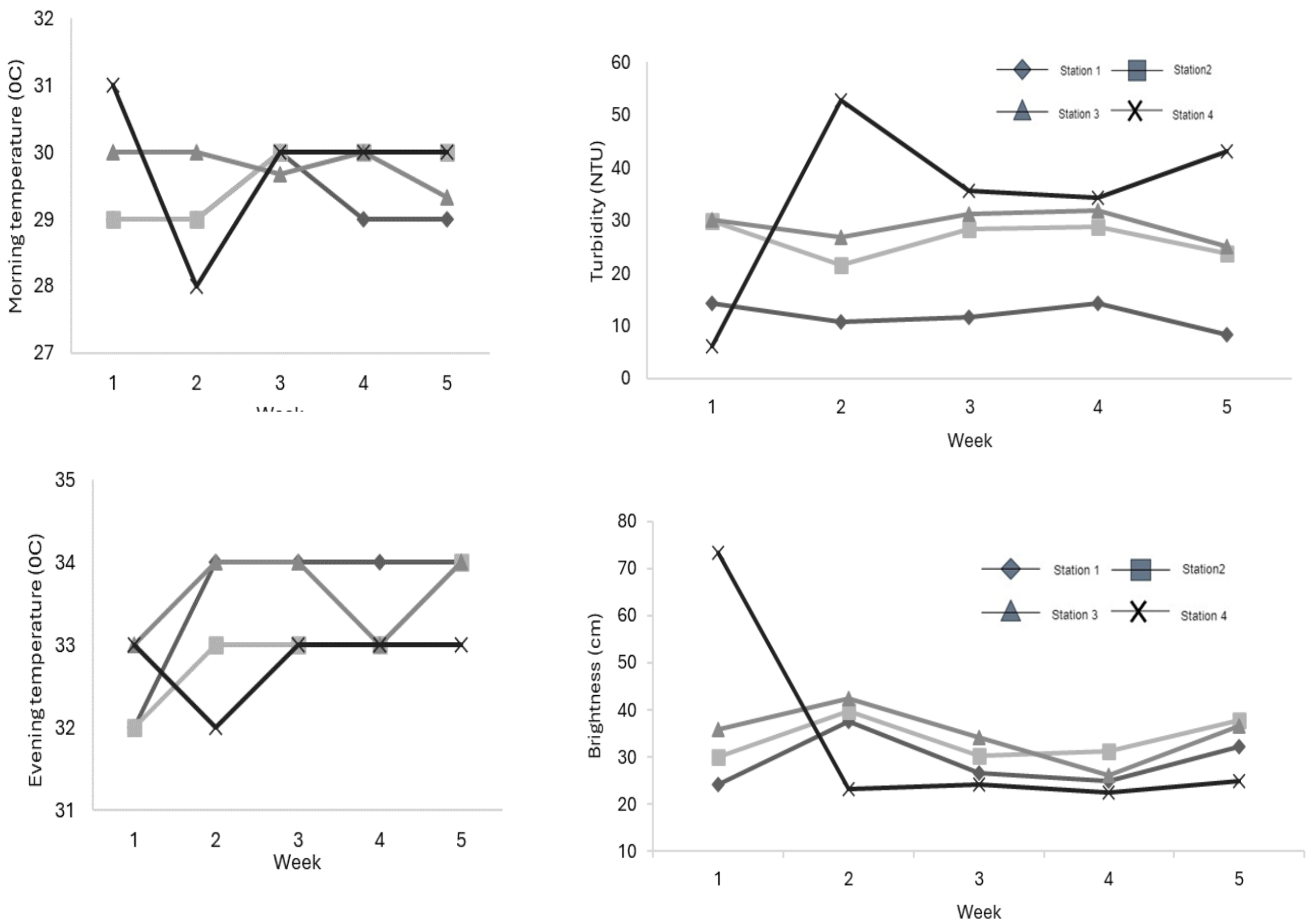

Figure 2. Physical parameter in sampling location.

Table 1. Feasibility assessment system for water quality for vannamei shrimp cultivation.

Parameter	Range	Value (N)	Category (B)	Score (N x B)	Reference
Temperature	28 – 32	4	3	12	Maritime and Fisheries Government Regulation No. 75 (2016)
	33 – 36	3		9	
	24 – 27	2		6	
	< 24 or > 36	1		3	
Turbidity	50 - 85	4	2	8	Boyd and Tucker (1998)
	25 – 49	3		6	
	> 85	2		4	
	< 25	1		2	
Brightness	30 – 45	4	2	8	Maritime and Fisheries Government Regulation No. 75 (2016)
	20 – 29,9	3		6	
	< 20	2		4	
	> 45	1		2	
pH	7,5 – 8,5	4	3	12	Maritime and Fisheries Government Regulation No. 75 (2016)
	6,0 – 7,0	3		9	
	8,6 - 9	2		6	
	< 6,0 or > 9,0	1		3	
Salinity	15 – 25	4	3	12	Mohanty et al., (2018)
	26 – 35	3		9	
	5 – 14	2		6	
	< 5 or > 35	1		3	
DO	4,0 – 7,5	4	3	12	Maritime and Fisheries Government Regulation No. 75 (2016)
	3,0 – 3,9	3		9	
	> 7,5	2		6	
	< 3,0	1		3	
Alkalinity	100 – 150	4	1	4	Maritime and Fisheries Government Regulation No. 75 (2016)
	151 – 250	3		3	
	> 250	2		2	
	< 100	1		1	
Organic matters	< 55	4	1	4	Maritime and Fisheries Government Regulation No. 75 (2016)
	55 – 100	3		3	
	101 – 150	2		2	
	> 150	1		1	
BOD_5	< 3	4	1	4	Farkan *et al.*, (2017) and Effendi (2003)
	4 – 7	3		3	
	7 – 10	2		2	
	> 10	1		1	
TAN	< 0,1	4	2	8	SNI 01-7246-2006.
	0,2 – 0,5	3		6	
	0,6 – 1,0	2		4	
	> 1,0	1		2	
Nitrit	< 0,01	4	2	8	Maritime and Fisheries Government Regulation No. 75 (2016)
	0,01 – 0,1	3		6	
	0,2– 1,0	2		4	
	> 1,0	1		2	
Nitrate	0,5	4	1	4	Maritime and Fisheries Government Regulation No. 75 (2016)
	0,6 – 1,0	3		3	
	> 1	2		2	
	> 0,5	1		1	
Phosphate	>1,0	4	1	4	Maritime and Fisheries Government Regulation No. 75 (2016)
	0,6 – 1,0	3		3	
	0,1 – 0,5	2		2	
	< 0,1	1		1	
Pb	< 0,005	4	2	8	Maritime and Fisheries Government Regulation No. 75 (2016)
	0,005 – 0,01	3		6	
	0,01 – 0,03	2		4	
	> 0,03	1		2	
Total of Vibrio	0	4	2	8	Maritime and Fisheries Government Regulation No. 75 (2016)
	1 – 100	3		6	
	101 – 1000	2		4	
	> 1000	1		2	
Total common bacteria	10^3 - 10^4	4	1	4	Kharisma dan Manan (2012)
	10^4 - 10^5	3		3	
	10^5 – 10^6	2		2	
	> 10^6	1		1	
Phytoplankton density	> 1,0	4	2	8	Meiriyani et al. (2011)
	0,6 – 1,0	3		6	
	0,1 – 0,5	2		4	
	< 0,1	1		2	

Chemical parameter

Water chemistry parameters from each station are shown in Figure 3.

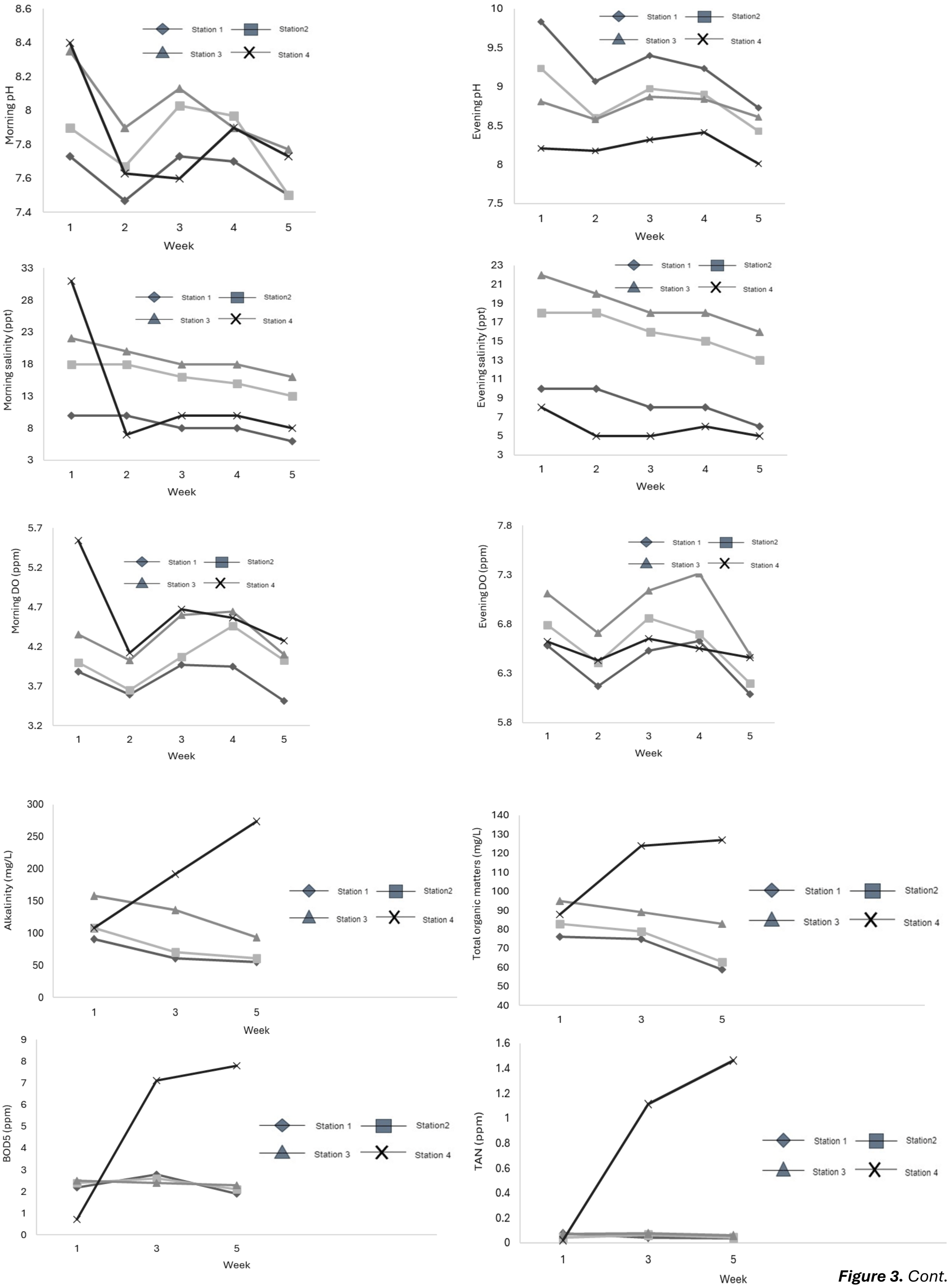

Figure 3. *Cont.*

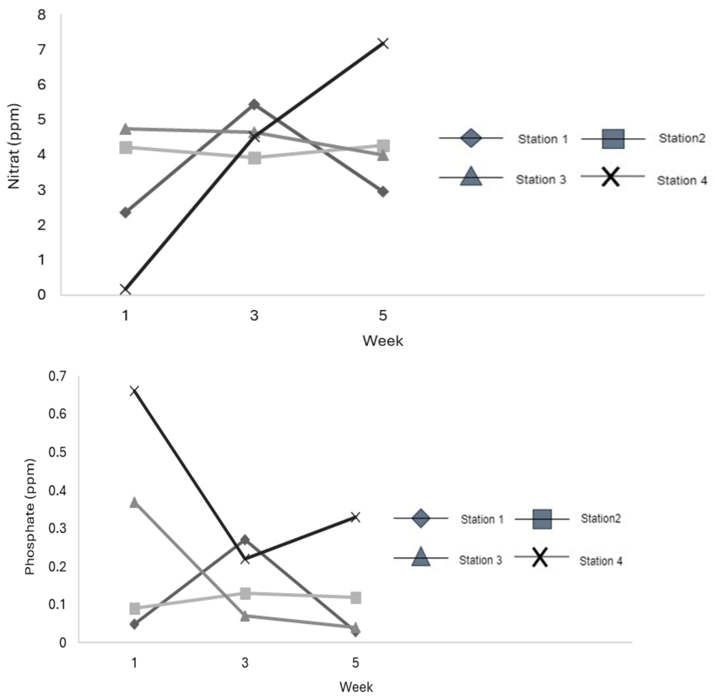

Figure 3. Chemical parameter in sampling location.

Biological parameters

The biological parameters of pond water are shown in Figure 4.

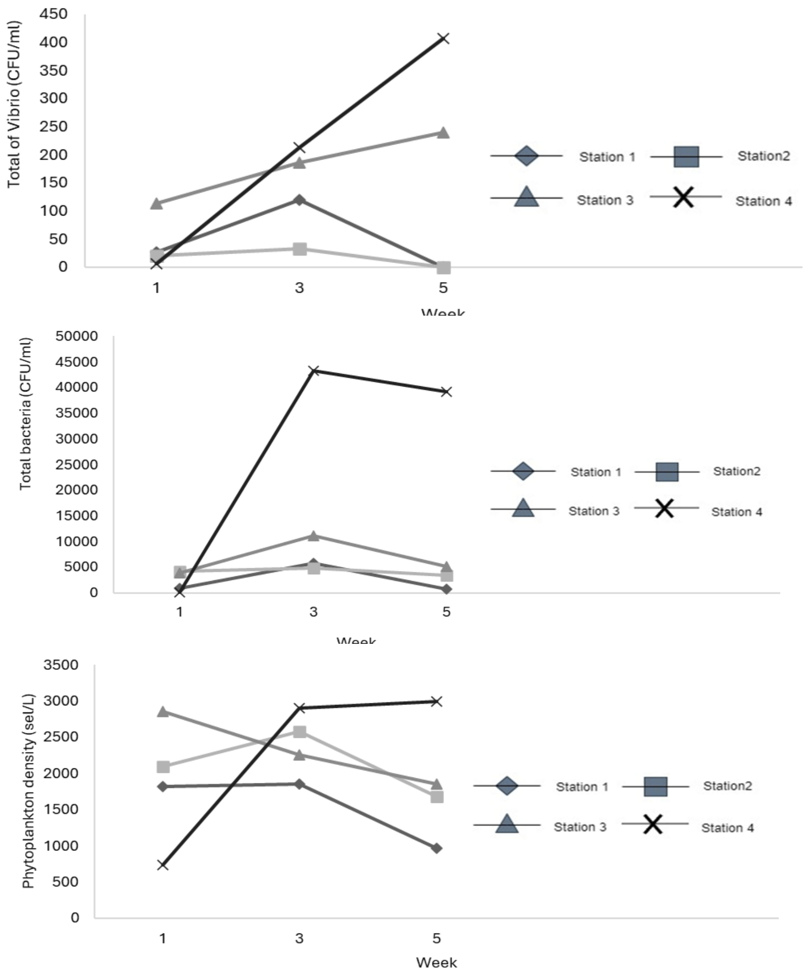

Figure 4. Biological parameter in sampling location.

The values of the dominance index (C), diversity index (H') and uniformity index (E) for each research station are presented in Table 3.

Table 3. Dominance Index (C), Diversity Index (H'), and Uniformity Index (E) values.

Parameter	Station			
	1	2	3	4
Diversity index (H')	2,28	2,13	2,34	2,64
Uniformity index (E)	0,81	0,81	0,84	0,88
Dominance index (C)	0,13	0,15	0,12	0,08

Evaluation of the feasibility of vannamei shrimp culture water quality

The results of the scoring and weighting of water quality suitability parameters for vannamei shrimp cultivation activities showed in Table 4.

Table 4. Scoring results and water quality feasibility levels for vannamei shrimp cultivation activities.

Parameter	Value	Result					
		Station 1			Station 2		
		Result	Score	Category	Result	Score	Category
Temperature	3	31,50	12	Very suitable	3130	12	Very suitable
Salinity	3	8,40	6	Conditionally appropriate	16,00	12	Very suitable
Turbidity	2	11,81	2	Not suitable	26,45	6	Suitable
Brightness	2	29,10	6	Suitable	33,83	8	Very suitable
pH	3	8,44	12	Very suitable	8,32	12	Very suitable
Dissolved oxygen	3	5,57	12	Very suitable	5,82	12	Very suitable
Alkalinity	1	69,22	1	Not suitable	79,56	1	Not suitable
Total organics matter	1	70,00	3	Suitable	75,11	3	Suitable
BOD_5	1	2,30	4	Very suitable	2,39	4	Very suitable
TAN	2	0,05	8	Very suitable	0,05	8	Very suitable
Nitrit	2	0,02	6	Suitable	0,03	6	Suitable
Nitrate	1	3,59	2	conditionally appropriate	4,13	2	conditionally appropriate
Phosphate	1	0,12	2	conditionally appropriate	0,11	2	conditionally appropriate
Lead (Pb)	2	<0,005	8	Very suitable	<0,005	8	Very suitable
Total Vibrio	2	48,89	6	Suitable	17,78	6	Suitable
Total Bacteria	1	2.451,11	4	Very suitable	4.144,44	4	Very suitable
Phytoplankton density	2	1.547,62	8	Very suitable	2.118,29	8	Very suitable
Total score			102			114	

Discussion

Water quality condition

Temperature measurements ranged from 28 to 34 ^{0}C with an average of 31,45 ^{0}C. Variations in location and timing of measurement often result in disparities in temperature readings. According to Maritime and Fisheries Government Regulation No. 75 (2016), the optimal water temperature is between 28 and 32 ^{0}C. The maximum temperature has exceeded the optimal range limit for the growth of vannamei shrimp. According to Budiardi (2008), the vannamei shrimp species can thrive at water temperatures ranging from 20 to 36 ^{o}C.

The optimal range for maintaining turbidity levels is between 25 and 80 NTU. Turbidity levels below 25 NTU do not have any detrimental effects on aquatic biota; however, levels above 80 NTU have been considered hazardous (Boyd and Tucker, 2012). The investigation measured turbidity values ranging from 6.17 to 52.80 NTU in the water source streams. At the pond plot station, the NTU ranges from 8.40 to 31.77. This circumstance indicates that the turbidity values determined throughout the investigation remain safe for the agricultural activities being conducted. However, an NTU value below 25 suggests that a significant amount of sunlight can penetrate the water due to the scarcity of suspended particles. The increase in turbidity in ponds is caused by the substantial buildup of organic matter derived from faeces and residual feed, which stimulates the proliferation of phytoplankton to its maximum extent. In contrast, the reduction in the turbidity values might be attributed to the dilution caused by rainwater. The primary factor influencing turbidity in aquaculture ponds is the density of plankton, however, the presence of suspended particles in the water also contributes to this phenomenon. According to Boyd & Boyd (2020), the presence of plankton in the water can result in various colours, such as green, yellow, blue-green and brown. Optimal turbidity refers to turbidity that arises from the presence of microorganisms or plankton. Turbidity is a measure of the number of individual plankton, which are microorganisms that float and move with the water. Furthermore, the presence of phytoplankton in the water of cloudy ponds might dampen the variations in diurnal temperature, thus maintaining warmth throughout the night.

Brightness refers to the uppermost threshold of the capacity of light to permeate the layer of water at a specific depth. The brightness measurements obtained during the research varied between 22.50 and 73.33 cm, while the water depth ranged from 26.67 to 73.30 cm. The maximum luminosity of 73.33 cm was recorded at station 4. The optimal recommended brightness value, as stated in Maritime and Fisheries Government Regulation No. 75 (2016), is between 30 and 45 cm, with a depth of 80 cm. The brightness value observed during the study was classified as high in relation to water depth, making it unsuitable for promoting the growth of vannamei shrimp. The Vannamei shrimp is an aquatic organism that prefers dark environments to protect and facilitate its foraging activities. Shrimp activity at night can be disturbed if sunlight penetrates the water in the pond with high intensity.

pH, a water quality parameter, measures the degree of acidity. It is a unitless number that fluctuates throughout the day according to the concentration of carbon dioxide (CO2) in water. The pH measurements obtained during the investigation varied between 7.47 and 9.83. The pH level peaked at 9.83, as determined at station 1. The recommended pH range for the growth of vannamei shrimp, as specified in Maritime and Fisheries Government Regulation No. 75 (2016), is between 7.5 and 8. According to Edhy et al., (2010), the optimal pH range for shrimp growth is between 6 and 9. However, a pH value below 6 or below 9, specifically in the range of 4 to 6 or 9 to 11, can inhibit growth. Furthermore, extremely low or high pH values, namely below 4 or above 11, can result in the mortality of shrimp. This demonstrates that the pH value of 7.47 is within the ideal range, but water conditions with a pH of 9.83 will hinder growth without causing mortality.

Salinity refers to the concentration of dissolved salts in water. Salinity plays a crucial role in the regulation of the osmoregulation process. This process will remain undisturbed as long as the salt concentration remains within the appropriate range. Maximize the efficiency of the energy obtained from food for growth. The salinity measurement findings ranged from 5 to 31 ppt. Vannamei shrimp are euryhaline, meaning they can survive in a wide range of salt levels. However, the minimum and maximum values recorded during the observations did not fall within the optimal range for the growth of vannamei shrimp, as specified by Mohanty *et al.,* (2018) which is 15 – 25 ppt.

Dissolved oxygen is essential for the respiration of vannamei shrimp and phytoplankton. Additionally, decomposer bacteria rely on dissolved oxygen to facilitate the breakdown of organic compounds. The measured dissolved oxygen values, ranging from 3.51 to 8.11, adequately satisfy the necessary conditions to promote optimal growth of vannamei shrimp during the raising process. According to Maritime and Fisheries Government Regulation No. 75 (2016), it is recommended that the concentration of dissolved oxygen in the growing activities of vannamei shrimp should be greater than 3 ppm. The concentration of dissolved oxygen in traditional technological applications depends on the direct diffusion process of oxygen from the atmosphere into the water and the photosynthetic activity of phytoplankton without the aid of a mechanism to enhance the oxygen supply in the pond.

Alkalinity ranged from 55.33 to 274.67 mg/L over the research. The highest alkalinity was 274.67 mg/L at station 4. Shrimp pond water should have >100 mg/L alkalinity (Makmur et al., 2018 and Roy et al., 2010). According to Maritime and Fisheries Government Regulation No. 75 (2016), vannamei shrimp thrive best at 100–250 mg/L alkalinity. Consequently, station 1's lowest alkalinity of 55.33 mg/L does not meet the criteria. Know the alkalinity content in agriculture as it buffers pH and prevents daily changes. When alkalinity is high, morning and evening pH differences are more diminutive.

Total organic matter refers to the quantity of organic matter present in water, whether it is dissolved, suspended, or colloidal. The research yielded organic matter measurements ranging from 58.67 to 126.67 mg/L. The maximum concentration of organic material was 126.67 mg/L, as determined at station 4. Compared to the limit of organic material set by Maritime and Fisheries Government Regulation No. 75 (2016) at 55 mg/L, all organic material obtained throughout the investigation exceeded the maximum threshold. Traditional technology is linked to the pond plots' 58.67 mg/L organic matter concentration. Traditionally managed ponds use natural and artificial feed sparingly. Low shrimp excretion and feed intake into ponds due to low stocking density reduce organic matter accumulation.

The BOD5 analysis is carried out to assess the level of organic material pollution present in the ponds, particularly in the water sources used. The BOD5 value was measured to range from 0.73 to 7.80 ppm. The water supply stream of station 4 produced the minimum and maximum levels of BOD5 observed during the study. This water is considered unpolluted as its value does not exceed 10 ppm (Effendi, 2003). Meanwhile, the concentration of the substance in the pond plots varies between 1.90 and 2.83 parts per million (ppm). An ideal range for shrimp cultivation is a BOD5 level below 3 ppm, as suggested by Farkan et al., (2017). The presence of organic matter derived from household waste and agriculture, which can be decomposed by aerobic bacteria, contributes to an increase in the value of BOD5.

The study examined total ammonia nitrogen (TAN), which is the concentration of poisonous nonionized ammonia (NH3) and harmful ammonium ions (NH_4^+). Vannamei shrimp thrive best with 0.1–1.0 mg/L TAN (Zweig et al., 1999 & SNI 01-7246-2006). The TAN values measured during the investigation ranged from 0.02 to 1.46 ppm. The water supply stream of Station 4 had the lowest and highest TAN levels. Water for the vannamei shrimp production is unsuitable because the maximum value exceeds the required threshold. If the ammonium (NH_4^+) level is higher than ammonia (NH_3), vannamei shrimp can survive a high TAN value. The existence of nitrogen-containing waste organic compounds leads to an elevation in TAN concentrations. Traditional vannamei shrimp-raising ponds exhibit lower total ammonia nitrogen (TAN) levels than intensive or super-intensive systems.

Nitrite (NO_2) is a measure of water quality that is influenced by dissolved oxygen during the nitrification process, affecting its stability. The nitrite content is derived by the oxidation of ammonia molecules by Nitrosomonas bacteria. The nitrite value generally exhibits a lesser magnitude than the TAN. The research yielded nitrite concentrations ranging from 0.01 to 0.08 ppm at station 4. The nitrite content reached during the study was above the recommended limit stated in Maritime and Fisheries Government Regulation No. 75 (2016), a maximum of <0.01 ppm. Vannamei shrimp could withstand nitrite levels ranging from 0.1 to 1.0 parts per million (ppm), as reported by Syafaat et al., 2012. The nitrite content in water is dependent on ammonia and dissolved oxygen. Nitrosomonas bacteria oxidize ammonia to nitrite, while Nitrobacter bacteria oxidize nitrite to nitrate compounds if oxygen is available. This lowers nitrite levels. If the undissolved oxygen is low and the nitrite content is high, the nitrification chain is not complete, stopping the reduction of nitrite compounds.

Under aerobic conditions, nitrate (NO_3) dominates water more than ammonia and nitrite. Nitrate feeds phytoplankton. Thus, the nitrate content determines the water fertility. The complete breakdown process raises water nitrate and reduces nitrite. Nitrate values during the investigation ranged from 0.17 to 7.18 ppm. Station 4 has the lowest and highest nitrate in the flow of the water source. Nitrate levels in the three pond plots were 2.36–5.44 ppm. Traditional vannamei shrimp cultivation in Maritime and Fisheries Government Regulation No. 75 (2016) requires 0.5 ppm nitrate. This indicates that most nitrate values surpass the threshold. Astuti et al. (2016) found that nitrate levels greater than 0.2 mg/L can produce eutrophication and blooming due to the development of phytoplankton.

Phosphate is a vital macronutrient found in water, along with nitrate, that is essential for the growth of phytoplankton and aquatic plants. The predominant chemical structure of phosphate in water is orthophosphate. The measured phosphate values during the research ranged between 0.03 and 0.66 ppm. The value of 0.03 ppm detected at station 1 falls below the acceptable requirements, indicating that it does not meet the necessary criteria. The lowest acceptable phosphate concentration for vannamei shrimp production activities, as stated in Maritime and Fisheries Government Regulation No. 75 (2016), is 0.1 parts per million (ppm). The low concentration of phosphorus observed at this site is a consequence of the lack of a fertilization procedure during the preparation of the pond. However, it is a consistent fact that phytoplankton will always absorb and utilize phosphate and nitrate for photosynthesis (Ulqodry et al., 2010). The station with the highest concentration of phosphate readings was station 4, with a measurement of 0.66 ppm. It is widely recognized that the movement of water sources includes the movement of household garbage, such as detergent waste. Areas near residential zones, fish farming facilities, and agricultural activities exhibit elevated phosphate levels.

Lead (Pb) is an unwanted heavy metal in water. Lead accumulates in organisms and harms the people who consume it. All lead measurements during the research yield the same value: <0.005 ppm. Maritime and Fisheries Government Regulation No. 75 (2016) sets the source water lead quality at 0.03 ppm and the traditional maintenance of the vannamei shrimp pond at 0. Due to community activities, this place could be contaminated with lead, yet the sample water did not contain lead. Because lead can follow the river and settle to the bottom, water lead concentrations are low or zero. Because heavy metals travel with water, their concentrations diminish.

Vibrio bacteria are a kind of pathogenic bacteria that tend to infect vannamei shrimp due to favourable conditions during the growth phase. Vibrio bacteria, acting as opportunistic infections, exclusively target shrimp with compromised immune systems. The observed values for Vibrio bacteria during the investigation ranged between 0 and 406.67 CFU/ml. Station 4 had the highest accumulation of Vibrio bacteria. The presence of Vibrio bacteria is considered undesirable in cultivating vannamei shrimp, as stated in Maritime and Fisheries Government Regulation No. 75 (2016), where the acceptable limit is 0 CFU/ml. According to Kharisma & Manan (2012), the minimal level of Vibrio bacteria needed to develop vibriosis sickness is 10,000 CFU/ml, as indicated by the authors. This shows that while the maximum amount of Vibrio bacteria collected during the study has exceeded the desired quality standard, it will not result in vibriosis symptoms.

The Vibrio bacteria discovered were of the yellow and green variety. Yellow Vibrio bacteria, namely *Vibrio alginolyticus*, can alter the colour of TCBS media to yellow. This is due to their ability to ferment sucrose and lower the pH of TCBS, resulting in an acidic environment. As a result, these bacteria are commonly referred to as yellow Vibrio bacteria. The prevalence of Vibrio bacteria during observation is believed to be caused by the buildup of organic matter in pond sediments and the combination of low water temperatures, particularly at night and during rainfall. The total number of general bacteria refers to the population of decomposer bacteria. The microorganisms found in the waterways serve the purpose of decomposing organic substances into simpler molecules. The study recorded a range of 146.67 to 43,333.33 CFU/ml for the total common bacteria observed. The maximum value was achieved at station 4. The lowest threshold for common bacteria in waterways is 1,000,000 CFU/ml. When the threshold is exceeded, there is a risk of widespread mortality among shrimp raised in ponds (Kharisma and Manan, 2012). Therefore, the total quantity of common bacteria remains below the minimum threshold required to have detrimental effects on vannamei shrimp. The presence of many diverse bacteria species effectively controls the growth of Vibrio bacteria, preserves the quality of the water used for shrimp production, minimizes the occurrence of diseases and stresses, promotes faster growth, and improves the survival rate of vannamei shrimp (Herdianti et al., 2015).

The typical comprehensive technology system, which supplies artificial feed, can use phytoplankton in ponds to feed shrimp and provide dissolved oxygen. Nitzschia acicularis, Cyclotella meneghiniana, Triceratium favus, Chaetoceros atlanticus, Navicula transitans, Rhizosolenia setigera, and Amphora coffeiformis are common species in Bacillariophyta. Diatoms, commonly known as Bacillariophyta, are phytoplankton found worldwide that can flourish under numerous circumstances (Vinayak *et al.,* 2022). The abundance of phytoplankton ranged from 736.96 to 2,998.87 cells per liter, averaging 2,054.52. Stations 1 and 4 had the lowest and highest average values, respectively. Station 4 exceeded 605 cells/L, indicating a significant abundance (Meiriyani et al., 2011). Nitrate and phosphate concentrations, which are necessary for cell growth, promote phytoplankton growth. Insufficient water nitrogen causes phytoplankton shortages.

The taxa in Chlorophyta, Cyanophyta, and Bacillariophyta are numerous because they can adapt to favourable environmental conditions. Cyanophyta develop faster than other classes because they absorb atmospheric nitrogen. The high concentration of phosphate, averaging 0.20 ppm, stimulates the growth of Cyanophyta phytoplankton due to its nutrients. Due to the divisions of the Chlorophyta and the Bacillariophyta, aquaculture ponds should support phytoplankton. These two classes are natural food sources and increase oxygen from the water column. Due to their potential to produce poisons, Cyanophyta and Dynophyta species produce nongrowing phytoplankton (Budiardi et al., 2007). *Microcystis panniformis*, *Anabaena flosaquae*, and *Oscillatoria limosa* are Cyanophyta species that release poisons during flowering.

The Shannon-Wienner diversity index values observed during the study varied from 2.13 to 2.64, indicating moderate diversity (1 < H' < 3). This suggests that the phytoplankton community is stable and consists of various individuals rather than being dominated by one or two forms of phytoplankton. In addition, the water quality is classified as mildly contaminated (Nugroho, 2006). The value of the phytoplankton dominance index is calculated to determine the prevalence of a specific type of phytoplankton in a body of water. The calculation yields values ranging from 0.08 to 0.15. Station 4 had the lowest phytoplankton dominance index, with a value of 0.08, while station 2 had the highest value of 0.15. The value obtained by each station is around 0, suggesting that no genus prevails over other species, indicating a state of stability within the community (Nugroho, 2006). The uniformity index measures the spread uniformity of the phytoplankton genus. The homogeneity index is 0.81–0.88. Stations 1 and 2 had the lowest homogeneity index, while station 4 had the highest. The values at each station were close to 1, indicating a homogeneous distribution of genus (Nugroho, 2006).

Water quality feasibility

Station 4 had the lowest water quality score, and station 3's pond plots were the highest. Each feasibility class station scored 102, 114, 116, and 101, respectively. The total score for pond water is better than 80, and it has promising water quality characteristics without any concerns, making it high (S1). Turbidity and alkalinity are not suitable for computation. Two irrelevant parameters do not affect the survival or well-being of vannamei shrimp. However, other water quality parameters affect vannamei shrimp development and survival. Pond waters are classified as having a high level of appropriateness (S1). The ideal growth of vannamei shrimp requires 8 parameters, while station 2 requires 10 parameters, and station 3 requires 11 parameters. Currently, a total of six criteria are being considered in relation to water sources. The current scenario demonstrates that the conventional vannamei shrimp ponds at this research site are suitable for further use as aquaculture zones.

Conclusions

Water quality assessment, conducted through scoring method calculations, indicates that source water quality and pond maintenance are highly suitable (S1) in terms of feasibility. The water quality characteristics of the ponds are favorable and do not pose any hindering factors. Considering optimal water quality, it is advisable to maintain traditional vannamei shrimp ponds in the Rancong pond region of Lhokseumawe City as aquaculture sites.

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Authorship contribution

LTY: Conceptualization, methodology, investigation, resources, sample processing and analysis, data curation, formal analysis, visualization, writing - original draft preparation, writing - review and editing. **RE**: Methodology, writing - review and editing, supervision. **MK:** Methodology, writing - review and editing, supervision. All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Data availability

Datasets are available from the corresponding author upon reasonable request.

Conflict of interest

On behalf of all authors, the corresponding author states that there are no conflicts of interest.

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