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Evaluating the quality of aquatic environment on the Planktonic-Index of Biotic Integrity (P-IBI) based whiteleg shrimp *Litopenaeus vannamei* (Boone, 1931) pond

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Abstract. *Akbarurrasyid M, Prajayati VTF, Sofian A, Katresna M. 2023. Evaluating the quality of aquatic environment on the Planktonic-Index of Biotic Integrity (P-IBI) based whiteleg shrimp* Litopenaeus vannamei *(Boone, 1931) ponds. Biodiversitas 24: 4845-4853.* Plankton is one of the biotic indicators used to evaluate the quality of the aquatic environment in the ponds. This study aims to find out the quality of the aquatic environment of the whiteleg shrimp *Litopenaeus vannamei* (Boone, 1931) ponds using Planktonic-Index Biotic of Integrity (P-IBI). Samples were collected in intensive *L. vannamei* farming in Pandeglang, Banten, and analyzed by the P-IBI method using 4 categories and 35 attributes. Matrix attributes include community composition, number of species, species density and species diversity. The P-IBI value is compared with the assessment category to obtain the status of aquatic environmental quality. The environmental quality assessment categories are: very good (83-100%), good (73-82%), moderate (57-72%) and bad (0-56%). The results of the study showed the assessment of Community Composition (CC) of 66 (66%) and the scoring of Amount of Species (AS) of 65 (59.09%) on the attributes of the number of Bacilloryophycea, percentage of Cyanophycea, Dinophyceae, and Protozoa. The scoring of Species Density (SD) obtained 65 (59.09%) on attributes of the abundance of Chlorophyceae and Bacilloryophycea and the low abundance of Dinophyceae and Protozoa. Meanwhile, the scoring of Species Diversity (SDI) obtained a maximal score of 30 (100%), which showed that the species diversity of plankton based on the Shannon-Wiener Index (H'), Margalef Index (E), and Pielou Index (D) was still in good condition, the species diversity was stable, and there were no dominating species. The P-IBI score obtained was in the moderate category for *L. vannamei* farming activities.

Keywords: *Litopenaeus vannamei*, P-IBI, plankton, species density, species diversity

INTRODUCTION

The environment is an important factor in the farming activities of whiteleg shrimp *Litopenaeus vannamei* (Boone, 1931) ponds. Whiteleg shrimp *L. vannamei* can grow maximally in an aquatic environment that is appropriate to the requirements. *Litopenaeus vannamei* grows and increases appetite at 29-31°C (Tacon et al. 2013), while changes in the bad aquatic environment can cause disease (Saputra et al. 2023). Water quality is the main factor in the emergence of disease-causing pathogenic bacteria and has a direct impact on the cultivation of *L. vannamei* (Chumpol et al. 2017). Variations in cultivation environments such as temperature, salinity, pH, dissolved oxygen and nutrients (Huang et al. 2023). Changes in the condition of the pond's aquatic environment are really specified by biotic components in the waters. One of the biotic components becoming the indicator of changes in the quality of the aquatic environment is plankton (Li et al. 2022)

Plankton is a microscopic organism (phytoplankton and zooplankton) that has function as the main producer in the waters. Phytoplankton has function as a primary producer, while zooplankton has a role as a secondary producer (Maznah et al. 2021; Akbarurrasyid et al. 2022; Ramlee et al. 2022). The characteristics of plankton as a producer show that plankton can absorb organic materials in the water so that they can be used to specify or evaluate the quality of the aquatic environment. Plankton is a great bioindicator in evaluating the quality of water in the aquatic system because it has an important role and is prone to ecological pressure (Hemraj et al. 2017). Evaluating the quality of the aquatic environment is generally performed to assess the ecology of the water so that it has an impact on the utilization of the aquatic environment for *L. vannamei* farming activities. The utilization of the aquatic environment for farming activities is very influential on the success of *L. vannamei* farming production. The success of *L. vannamei* farming in the ponds is specified by the proper management of the farming environment, including the presence of a plankton community in the pond environment (Inayah et al. 2023)

Plankton community in the pond varies and is specified by the availability of nutrition, temperature, and light intensity (Ramlee et al. 2022). The presence of various plankton communities in the pond environment can provide positive and negative impacts so they must be well managed. According to Zhang et al. (2022), the presence of *Thalassiosira* sp. plankton in the farming environment shows a significant impact on the performance of *L.*

vannamei growth and farming environment. *Thalassiosira* sp. absorbs nitrogen and phosphorus, reduces eutrophication, manages the water environment, inhibits the growth of *Vibrio parahaemolyticus*, and increases shrimp survival and production. Otherwise, some types of *Cyanophyta* plankton accelerate the growth rate of *Vibrio* sp. in the natural environment (Chatterjee and More 2023). Thus, the presence of planktons in the vannamei shrimp ponds must be considered comprehensively based on the composition of the genus, amount of species, species density, and species diversity using the Planktonik Index of Biotic Integrity (P-IBI) approach.

P-IBI is a method used to determine or evaluate the quality of lakes and river environments due to various ecological pressure so it can be used according to the ecological functions (Zhu et al. 2021). This study was conducted by adapting that concept to *L. vannamei* farming activities. P-IBI used biotic components (planktons) as an indicator of the quality of the pond environment. The p-IBI method was used to specify the ecological changes and health according to the characteristics of phytoplankton and zooplankton communities (Houssou et al. 2020; Huang et al. 2022; Li and Li 2023). P-IBI approach in the *Litopenaeus vannamei* farming environment was conducted comprehensively by considering the ecological functions of plankton and supporting farming activities. This study aims to find out the quality of the aquatic environment of the vannamei shrimp ponds using P-IBI analysis.

MATERIALS AND METHODS

Study area

This study was conducted in Pandeglang, Banten, Indonesia (Figure 1) for two months (October to November 2022). The aquatic environment observed was *Litopenaeus vannamei* farming ponds with the P-IBI method.

Procedures for collecting and observing plankton samples

Plankton sampling was carried out every 7 days at a depth of 50 cm from the surface of the pond water and was collected during the rearing period of *L. vannamei* using a 100 mL sample bottle. Sampling was carried out at 4 points of the observed pond. Sampling during the maintenance period was carried out temporally 8 times without repeating samples. Samples collected were fixed using Lugol and were brought to the laboratory to be identified (Yang et al. 2017; Amorim and Moura 2021). Identification of plankton used a hemocytometer covered using preparation glass (Heinle et al. 2021). Hemocytometer was observed using a microscope with a magnification of 10 times. The results of observation were recorded in the plankton observation logbook for P-IBI analysis.

Planktonic analysis-biotic of integrity index

Collected plankton identification data were analyzed using P-IBI analysis. P-IBI analysis aimed to obtain the quality status of the pond environment comprehensively based on the structure of the plankton community. Stages of P-IBI analysis were started by arranging the P-IBI matrix, P-IBI assessment, and evaluating the quality of the aquatic environment according to P-IBI categories. The P-IBI matrix was arranged into 4 categories with 35 matrix candidates (Li and Li 2023). Selecting matrix attributes embraced the structures of community, species, diversity, and uniformity (Feng et al. 2021). The matrix categories and attributes are grouped into 4, namely: Community Composition (CC), Number of Species (AS), Species Density (SD) and Species Diversity (SDI) (Zhu et al. 2021). The attribute assessment scores are divided into three assessment classes, namely: bad category (3 points), medium category (5 points) and good category (10 points). Assessment classes are determined individually based on the similarity of these values to the values found in the community (Li and Li 2023).

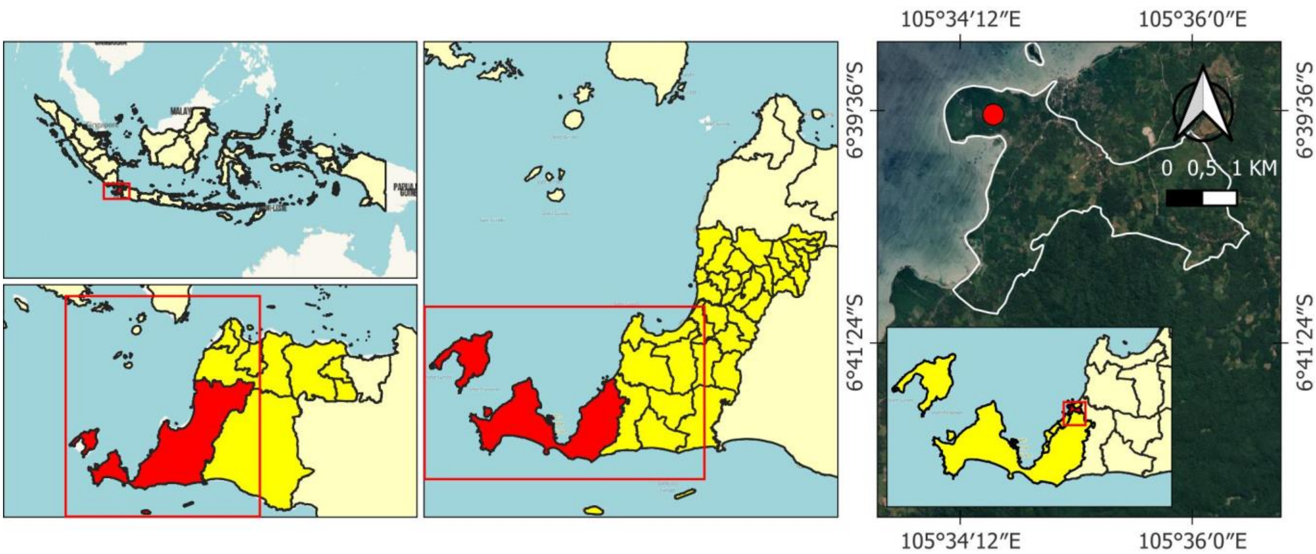

Figure 1. Research site in Sumur, Ujung Kulon, Pandeglang, Banten, Indonesia

The assessment of community composition and amount of species was conducted according to the observation results of identified plankton (Kostryukova et al. 2018). The observed plankton is compared with the plankton identification book (Al-Kandari et al. 2009). Identified plankton is one of the aquatic biological indicators that can be grouped by taxa and genus (Heinle et al. 2021). The plankton diversity was obtained using the Segwick Rafter object-glass method and quantitatively formulated using formulas (Palupi et al. 2022). Species diversity was calculated using the Shanno-Wiener index, Margalef index, and Pielou index (Heramza et al. 2021). P-IBI score was obtained according to the amount of score obtained from the sum of each category and attribute candidate obtained. P-IBI score was compared with the category of assessment to obtain the quality status of the aquatic environment. The category of assessment on environmental quality was: very good (83-100%), good (73-82%), moderate (57-72%), and bad (0-56%) (Li and Li 2023).

Analysis of water quality

Water quality is an important factor in *Litopenaeus vannamei* is farming activities. The measurement of temperature (ºC), dissolved oxygen (ppm), and pH was conducted in situ and daily with a standard multi-probe method, while the salinity was carried out using a refractometer (Pinho and Emerenciano 2021). The measurement of alkalinity (ppm), Total Ammonia Nitrogen (mg/L), Total Organic Mater (ppm), Calcium (ppm), and Magnesium (ppm) was conducted ex-situ using the titration method. The observation results of water quality were carried out by regression statistical analysis to find out the correlation among the parameters of water quality.

Statistic analysis

Statistic analysis in this study was divided into two: (i) matrix and attribute analyses according to the results of community composition, amount of species, species density, and species diversity (Zhang et al. 2019) and (ii) regression analysis toward the observation results of water quality (Feng et al. 2021)

RESULTS AND DISCUSSION

Plankton composition, abundance, and diversity

Plankton compositions found 5 groups and 31 genera (phytoplankton and zooplankton): (i) Chlorophyceae (4 genera), (ii) Cyanophycea (5 genera), (iii) Bacillaryophyceae (11 genera), (iv) Dinophyceae (7 genera), and (v) protozoa (4 genera). Most genera were found in the Bacillaryophyceae group, and the least was in Chlorophyceae and Protozoa. Furthermore, the highest abundance was found in Cyanophycea (739 ind/mL), and the lowest was found in Chlorophyceae (115 ind/mL). This showed that the amount of genus diversity had no correlation with the highest amount of abundance. The highest abundance score of Bacillaryophyceae in *L. vannamei* farming activities was highly required in farming activities. Bacillaryophyceae and Chlorophyceae have a high nutrition content and positively contribute to water quality (Roy and Pal 2015; Brito et al. 2016). Plankton composition, abundance, and diversity of *L. vannamei* ponds can be seen in Table 1.

The abundance of pond plankton experiences changes rapidly and dynamically because it is influenced by light, temperature, salinity, Carbon Dioxide (CO_2) and concentration of nutrients (Sugie et al. 2020; Pulsifer and Laws 2021). Light is highly required for the photosynthesis process of phytoplankton, while excess nutrient concentration can cause eutrophication characterized by low oxygen, high ammonia and phosphorus concentrations, and algae blooming (Li et al. 2022). Changes in plankton composition and abundance were really determined by farming treatment and farming times. Bacillariophyceae and Chlorophyceae dominate *L. vannamei* cultivation activities. The dominance of Bacillariophyceae in the aquatic environment is due to its cosmopolitan nature and grows well in various aquatic environments (Pratiwi et al. 2018).

Table 1. Plankton composition and abundance

Divisi	Genera	Amount (sp.)	Abundance (ind/mL)
Cynophyceae	*Oscillatoria*	1	514
	Ghambosperia	1	1
	Anabaena	1	11
	Mycrocystis	1	199
	Spirulina	1	14
Chlorophyceae	*Chlorella*	1	40
	Gleocystis sp.	1	64
	Scenedesmus	1	5
	Oocystis	1	6
Bacillariophyceae	*Surirella* sp.	1	36
	Pleurosigma	1	162
	Triceratulina	1	15
	Bacillaria	1	30
	Bellerochea	1	148
	Nitzschia	2	37
	Ceratulina	1	28
	Amphora	1	27
	Rhizosolenia	1	24
	Dittylum	1	22
	Coscinodiscus	1	44
Dinophyceace	*Chattonella*	1	4
	Gymnodinium	1	4
	Alexandrium	1	12
	Gonyaulax	1	21
	Amphidinium	1	25
	Branchionus	1	19
	Protoperidinium	1	60
Protozoa	*Cryptomonas*	1	160
	Favella	1	2
	Euplotes	1	11
	Vorticella	1	19
Diversity Index			
Number of Individuals			1745
Genera			31
Index Shannon-Wiener (H’)			2.598
Index Margalef (E)			0.756
Index Pielou (D)			0.127

The Bacillariophyceae group is a group that is abundant in the ecological environment and early phases of cultivation, namely: *Nitzschia, Amphora, Coscinodiscus, Dittylum* and *Rhizosolenia*. The Chlorophyceae group found in the early days of cultivation was Chlorella (Kumar et al. 2020; Qiao et al. 2020). Bacillariophyceae and Chlorophyceae are useful in improving water quality and inhibiting the growth of harmful microalgae, pathogenic bacteria, increasing body immunity and increasing cultivation success (Cao et al. 2014; Zhang et al. 2022). Variations of plankton composition and abundance directly correlated to the diversity of pond plankton. Variations in the composition and abundance of plankton are directly related to the diversity of pond plankton. Plankton diversity is related to the availability of nutrients. High levels of nutrients can cause changes in community or species composition (Sidabutar et al. 2016).

Diversity score of pond planktons according to the Shannon-Wiener Index (H') was 2.598, Margalef Index (E) was 0.756, and Pielou Index (D) was 0.127. Shannon-Wiener Index score obtained showed that planktons in the aquatic environment of *Litopenaeus vannamei* farming ponds had a very stable and good diversity level (H' = >2.4) for *Litopenaeus vannamei* farming (Palupi et al. 2022). The diversity score of *Litopenaeus vannamei* farming ponds was determined by farming management, including the quality of farming water and feeding. Feed management is a method to control waste in ponds. Feeding and providing probiotics can reduce the growth of Cyanobacteria (*Oscillatoria* sp. and *Anabaena* sp.) and increase the growth of *Chlorella* sp., *Oocystic* sp. (Chlorophyceae), *Nitzschia* sp., *Amphora* sp., *Coscinodiscus* sp., *Dittylum* sp. and *Rhizosolenia* (Bacillaryophyceae) (Lukwambe et al. 2019; Qiao et al. 2020; Palupi et al. 2022).

The uniformity score of pond planktons included in the high category (E = 0.756). The uniformity score >0.75 is a condition of a stable plankton community. The stable plankton community showed a high homogeneity level, which means that the abundance of plankton was relatively the same or there was no dominant species in *Litopenaeus vannamei* farming ponds. Otherwise, the lower the uniformity score in a community, it shows that the distribution of individuals from each genus or species is uneven or indicates the tendency of a community against domination by certain species or genera (Palupi et al. 2022).

The dominance index score obtained was 0.127, which showed that there was no dominance genus or species (D = <0.5). Higher the value of the Simpson and Shannon index indicates high diversity (Inayah et al. 2023). The domination of pond plankton was influenced by various factors, including the quality of water and the availability of nutrients in the pond. High diversity score shows that plankton can use nutrients for reproduction (Akbarurrasyid et al. 2022). The abundance of nutrients in the pond allows more phytoplankton (Palupi et al. 2022).

Planktonik-index biotic of integrity

P-IBI was carried out by identifying results obtained, which were then scored according to the categories of the biotic matrix that has been arranged (Table 2). Scoring P-IBI was divided into scoring Community Composition/CC (CC 1-10), Amount of Species/AS (AS 1-11), Species Density/SD (SD 1-11), and Species Diversity/SDI (SDI 1-3). The results of scoring from each component can be seen in Figure 2.

The results of scoring CC was 66 (66%) out of a maximum score of 100, while AS score was 65 (59.09%) out of a maximum score of 110. The highest CC and AS scoring component was in the attribute of the Number of Bacilloryophycea (sp.), the percentage of Cyanophycea (%), Dinophyceae (%), and Protozoa (%), while the lowest scoring component was in the attribute of the amount of Chlorophyceae. The abundance of Bacilloryophycea is required in farming activities because it has a high nutrient score, easy to digest, very good, especially for the survival of shrimp larvae, and is preferred by shrimp over other classes (Heramza et al. 2021; Soeprapto et al. 2023).

Otherwise, the minimal percentage of Cyanophycea, Dinophyceae, and Protozoa is very useful for farming activities, in which Cyanophycea causes the water to be green, blue, black, and less profitable because Cyanophycea produces a toxin that is dangerous for shrimp and causes death before harvest (Duan et al. 2018). Protozoa can be a parasite in shrimp farming activities. The attack of *Vorticella* sp. when molting causes infection in shrimp (Hafidloh and Sari 2019).

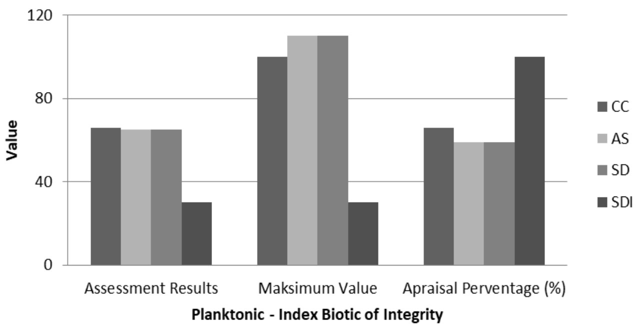

Figure 2. Scoring planktonic-index of biotic integrity

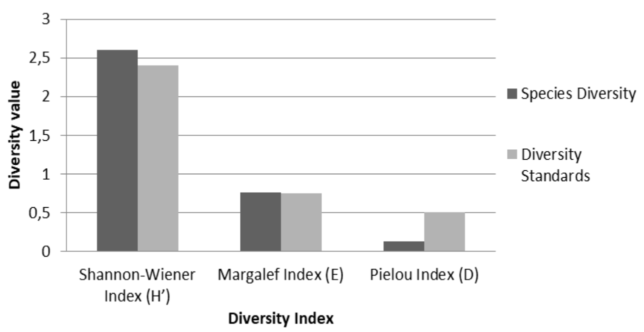

Figure 3. Species diversity index

Table 2. Matrix and scoring plankton-Index Biotic of Integrity (P-IBI)

Category	Matrix attributes	Abbreviation	Assessment scoring			Biotic results	Score
			3	5	10		
Community Composition (CC)	Number of Cyanophycea (sp.)	CC2	>6	3-5	<2	5	5
	Number of Chlorophyceae (sp.)	CC1	<2	2-4	>6	4	5
	Number of Bacilloryophycea (sp.)	CC3	<2	2-4	>6	11	10
	Number of Dinophycea (sp.)	CC4	>6	2-4	<2	7	3
	Number of Protozoa (sp.)	CC5	>6	2-4	<2	4	5
	Percentage Cyanophycea (%)	CC7	>66.65	33.33-66.64	<33.32	16,13	10
	Percentage Chlorophyceae (%)	CC6	<33.32	33.33-66.64	>66.65	12,90	3
	Percentage Bacilloryophycea (%)	CC8	<33.32	33.33-66.64	>66.65	35,48	5
	Percentage Dinophycea (%)	CC9	>66.65	33.33-66.64	<33.32	22,58	10
	Percentage Protozoa (%)	CC10	>66.65	33.33-66.64	<33.32	12,90	10
Amount of Species (AS)	Total Number of Species (sp.)	AS1	>22	11-21	<10	31	3
	Number of Species Cyanophycea (sp.)	AS3	>5	3-4	<2	5	3
	Number of Species Chlorophyceae (sp.)	AS2	1	2-4	>4	4	5
	Number of Species Bacilloryophycea (sp.)	AS4	<4	5-8	>9	12	10
	Number of Species Dinophyceae (sp.)	AS5	>6	3-5	<2	7	3
	Number of Species Protozoa (sp.)	AS6	>4	2-3	1	4	3
	Percentage Cyanophycea (%)	AS8	>81	41-80	<40	15,63	10
	Percentage Chlorophyceae (%)	AS7	<25	26-75	>76	12,50	3
	Percentage Bacilloryophycea (%)	AS9	<32	33-66	>67	37,50	5
	Percentage Dinophycea (%)	AS10	>85.26	28.6-85.25	<28.5	21,88	10
	Percentage Protozoa (%)	AS11	>76	26-75	<25	12,50	10
Species Density (SD)	Total Species Density (Ind/mL)	SD1	>2500	700-2500	<700	1764	5
	Cyanophycea Abundance (Ind/mL)	SD3	>495	247-494	<246	739	3
	Chlorophyceae Abundance (Ind/mL)	SD2	<38	39-76	>77	115	10
	Bacilloryophycea Abundance (ind/mL)	SD4	<191	192-382	>383	573	10
	Dinophycea Abundance (Ind/mL)	SD5	>97	49-96	<48	145	3
	Protozoa Abundance (Ind/mL)	SD6	>129	65-128	<64	192	3
	Cyanophycea Abundance Percentage (%)	SD8	>66.65	33.33-66.64	<33.32	41,89	5
	Chlorophyceae Abundance Percentage (%)	SD7	<33.32	33.33-66.64	>66.65	6,52	3
	Bacilloryophycea Abundance Percentage (%)	SD9	<33.32	33.33-66.64	>66.65	32,48	3
	Dinophyceae Abundance Percentage (%)	SD10	>66.65	33.33-66.64	<33.32	8,22	10
	Protozoa Abudance Percentage (%)	SD11	>66.65	33.33-66.64	<33.32	10,88	10
Species Diversity (SDI)	Shannon-Wiener Index (H')	SDI1	<1.2	1.21-2.4	>2.4	2.598	10
	Margalef Index (E)	SDI2	<0.4	0.41-0.6	>0.7	0.756	10
	Pielou Index (D)	SDI3	>0.7	0.41-0.6	<0.4	0.127	10
Total CC value							66
Total AS value							65
Total SD value							65
Total SDI value							30
Total P-IBI							226
Maximum value (100%)							350
Assessment Result ((total P-IBI / maximum value)*100)							64.57
Description of the results of the assessment							Moderate

SD score was 65 (59.09%) out of a maximal score of 110. The highest SD score components were obtained in the attributes of Chlorophycea abundance (ind/mL), Bacilloryophycea abundance (ind/mL), percentage of Dinophyceae abundance (%) and percentage of Protozoa abundance (%). The abundance of Chlorophyceae and Bacilloryophycea is required in pond farming activities as a natural food and oxygen booster in pond water (Saadaoui et al. 2020; Heramza et al. 2021). Otherwise, the low abundance of Dinophyceae (ind/mL) and Protozoa (ind/mL) is very useful for improving the survival of shrimp. Dinophyceae species, such as *Alexandrium tamarense* and *Prorocentrum minimum* can cause shrimp mortality and eutrophication in farming ponds (Brandenburg et al. 2017; Mu et al. 2019). Meanwhile, the SDI scoring component obtained a maximal score of 30 (100%), which showed that the diversity of plankton species according to the Shannon-Wiener Index (H'), Margalef Index (E), and Pielou Index (D) (Figure 3) was still in very good condition, species diversity was stable, and there were no dominance species. Generally, the P-IBI score obtained according to 4 categories and 35 matrix attributes was still in the moderate category for *L. vannamei* farming activities.

Water quality

Water quality is an influential factor in *L. vannamei* is farming activities. The changes in water quality into bad category can cause changes in the composition of plankton in the ponds, where several planktons in the ponds have direct and indirect roles as natural food that stimulates the growth of *L. vannamei* (Martins et al. 2016; Palupi et al. 2022), while some can have toxic effects on farming activities, such as Dinophyceae (Pérez-Morales et al. 2017). A healthy aquaculture environment requires algae balance (plankton), which is useful for farming organisms (Qiao et al. 2020). Thus, the quality of farming water must be well managed for farming sustainability. The water quality of *L. vannamei* farming can be seen in Table 3.

The results of the study showed that the water quality of *L. vannamei* ponds was entirely in accordance with the requirements according to the average score (mean ± standard deviation). The farming water quality experienced fluctuation during this study, which was caused by the natural environment and the influence of farming activities. Natural factors, such as weather, really influence the fluctuation of the water quality, while farming activities have the potential to cause fluctuation due to the increase of organic waste and ammonia from the feed residue, feces, and shrimp excretion (Hargreaves and Tucker 2004). TAN score (Figure 4) and TOM (Figure 5) excess the optimum score.

TAN score is the combination of nitrate, nitrite, and ammonia scores in the nitrogen cycle, and fluctuation of the TAN score, which excess optimal score influenced by nitrite and ammonia factors from feed residue and unutilized feed. A high TAN score influences the performance of shrimp gill in consuming oxygen and affects the growth rate of the shrimp and planktonic-nitrification process (Kumar et al. 2020).

Meanwhile, the fluctuation of TOM score is influenced by feed residue, feces, and organisms that die during farming activities so that it must be converted into protein by microorganisms such as heterotrophic bacteria, microalgae, and protozoa (Flores-Valenzuela et al. 2021). The high TOM score was influenced by the content of organic substances in the ponds, which were dissolved or suspended in the water causing the score of total organic meter to be higher. The high score of organic substances has a direct effect on the life of shrimp vannamei because they can reduce the level of dissolved oxygen and the formation of toxic compounds (Soeprapto et al. 2023).

Table 3. Water quality of *Litopenaeus vannamei* farming

Parameter	Value min-max (mean ± SD)	Optimum value	References
Temperature (°C)	27-31 (28.49 ± 0.56)	26-32	Fernández-gonzález et al. (2022)
Dissolved Oxygen (ppm)	4.35-7.57 (4.99 ± 0.45)	> 2	Doubek et al. (2018)
pH	7.55-8.41 (7.74 ± 0.07)	7.5-8.8	Chen et al. (2015)
Salinity (ppt)	24-25 (24.49 ± 0.50)	1-35.5	Wang and Zhang (2020)
Alkalinity (ppm)	144-247 (181.66 ± 36.45)	80-200	Chen et al. (2015)
Total Ammonia Nitrogen / TAN (mg/L)	0.57-3.17 (1.83 ± 1.12)	1.60-2.78	Duan et al. (2018)
Total Organic Matter / TOM (mg/L)	55.61-109.96 (78.30 ± 18.30)	< 82.16	Akbarurrasyid et al. (2022)
Calcium (ppm)	280-440 (360 ± 56.56)	134-773	Jaganmohan et al. (2018)
Magnesium (ppm)	1297-1603 (1435 ± 118.57)	<590	Iffat et al. (2018)
Hardness (ppm)	5700-7000 (6266 ± 500.66)	1908-7137	Jaganmohan et al. (2018)

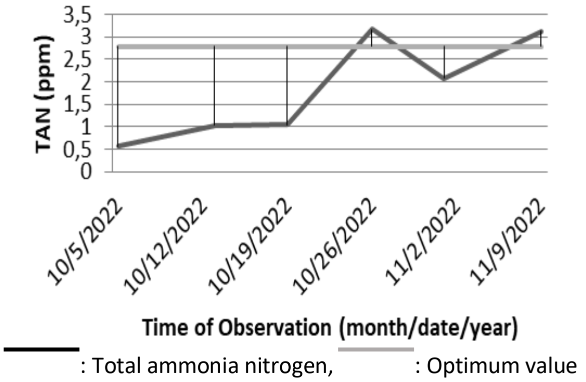

Figure 4. Fluctuation of Total Ammonia Nitrogen (TAN)

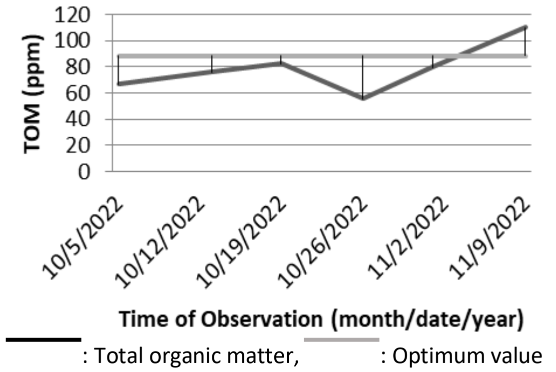

Figure 5. Fluctuation of Total Organic Matter (TOM)

Table 4. Multiple correlation test in water quality

Parameter	Temperature	DO	pH	Salinity	Alkalinity	TAN	TOM	Calcium	Magnesium	Hardness
Temperature	1.000									
DO	0.320	1.000								
pH	0.717	0.881	1.000							
Salinity	-0.471	-0.527	-0.556	1.000						
Alkalinity	0.524	0.225	0.388	-0.721	1.000					
TAN	0.643	0.261	0.456	-0.925	0.779	1.000				
TOM	0.293	0.097	0.198	-0.205	0.775	0.237	1.000			
Calcium	-0.639	-0.553	-0.729	0.000	0.163	0.016	0.092	1.000		
Magnesium	0.496	0.155	0.279	-0.896	0.782	0.943	0.330	0.144	1.000	
Hardness	0.413	0.088	0.189	-0.875	0.783	0.924	0.333	0.254	0.994	1.000

Fluctuations in water quality parameters mutually influence other water quality parameters. Based on the results of the correlation test (Table 4) showed that all water quality parameters of *Litopenaeus vannamei* farming ponds had various correlation levels. The highest correlation level was obtained in the parameters of temperature (R = 0,717), dissolved oxygen (R = 0,881), alkalinity (R = 0,783), and TAN (R = 0,943) compared to other parameters. The scores of temperature and dissolved oxygen have a positive correlation with pH, where the changes in pH to acid cause a decrease in the score of dissolved oxygen (Soares et al. 2020). Otherwise, the higher the water pH, the lower the calcium solubility. The alkalinity score had a positive correlation with TAN, TOM, Magnesium, and hardness. The alkalinity score increased along with the increase in the maintenance period. The early maintenance period causes a low TAN score because the conversion of organic decomposition is optimal (Chun et al. 2018). TAN score had a positive correlation with magnesium and hardness, while magnesium score had a positive correlation with hardness.

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