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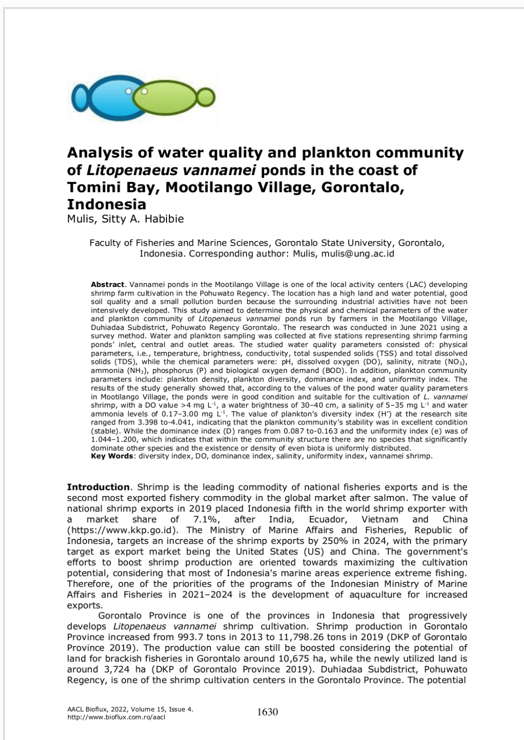

Analysis of water quality and plankton community of *Litopenaeus vannamei* ponds in the coast of Tomini Bay, Mootilango Village, Gorontalo, Indonesia

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Abstract. Vannamei ponds in the Mootilango Village is one of the local activity centers (LAC) developing shrimp farm cultivation in the Pohuwato Regency. The location has a high land and water potential, good soil quality and a small pollution burden because the surrounding industrial activities have not been intensively developed. This study aimed to determine the physical and chemical parameters of the water and plankton community of *Litopenaeus vannamei* ponds run by farmers in the Mootilango Village, Duhiadaa Subdistrict, Pohuwato Regency Gorontalo. The research was conducted in June 2021 using a survey method. Water and plankton sampling was collected at five stations representing shrimp farming ponds' inlet, central and outlet areas. The studied water quality parameters consisted of: physical parameters, i.e., temperature, brightness, conductivity, total suspended solids (TSS) and total dissolved solids (TDS), while the chemical parameters were: pH, dissolved oxygen (DO), salinity, nitrate (NO_3), ammonia (NH_3), phosphorus (P) and biological oxygen demand (BOD). In addition, plankton community parameters include: plankton density, plankton diversity, dominance index, and uniformity index. The results of the study generally showed that, according to the values of the pond water quality parameters in Mootilango Village, the ponds were in good condition and suitable for the cultivation of *L. vannamei* shrimp, with a DO value >4 mg L^{-1}, a water brightness of 30–40 cm, a salinity of 5–35 mg L^{-1} and water ammonia levels of 0.17–3.00 mg L^{-1}. The value of plankton's diversity index (H') at the research site ranged from 3.398 to-4.041, indicating that the plankton community's stability was in excellent condition (stable). While the dominance index (D) ranges from 0.087 to-0.163 and the uniformity index (e) was of 1.044–1.200, which indicates that within the community structure there are no species that significantly dominate other species and the existence or density of even biota is uniformly distributed.

Key Words: diversity index, DO, dominance index, salinity, uniformity index, vannamei shrimp.

Introduction. Shrimp is the leading commodity of national fisheries exports and is the second most exported fishery commodity in the global market after salmon. The value of national shrimp exports in 2019 placed Indonesia fifth in the world shrimp exporter with a market share of 7.1%, after India, Ecuador, Vietnam and China (https://www.kkp.go.id). The Ministry of Marine Affairs and Fisheries, Republic of Indonesia, targets an increase of the shrimp exports by 250% in 2024, with the primary target as export market being the United States (US) and China. The government's efforts to boost shrimp production are oriented towards maximizing the cultivation potential, considering that most of Indonesia's marine areas experience extreme fishing. Therefore, one of the priorities of the programs of the Indonesian Ministry of Marine Affairs and Fisheries in 2021–2024 is the development of aquaculture for increased exports.

Gorontalo Province is one of the provinces in Indonesia that progressively develops *Litopenaeus vannamei* shrimp cultivation. Shrimp production in Gorontalo Province increased from 993.7 tons in 2013 to 11,798.26 tons in 2019 (DKP of Gorontalo Province 2019). The production value can still be boosted considering the potential of land for brackish fisheries in Gorontalo around 10,675 ha, while the newly utilized land is around 3,724 ha (DKP of Gorontalo Province 2019). Duhiadaa Subdistrict, Pohuwato Regency, is one of the shrimp cultivation centers in the Gorontalo Province. The potential

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In general, the average productivity of ponds in Pohuwato Regency is 395 kg ha^{-1} of harvest resulting from the average area of pond mapping of 5 ha $plot^{-1}$ (Athirah et al 2012). The productivity of this pond is relatively low when compared to the value of the pond productivity in Pangkep Regency, which is worth 622 kg ha^{-1} by harvest with a pond area of 2.44 ha $plot^{-1}$ (Mustafa et al 2010) and Pinrang Regency 499 kg ha^{-1} by harvest with a pond area of 1.80 ha $plot^{-1}$ (Mustafa & Ratnawati 2007a). The study of water quality and plankton analysis is critical for sustainably increasing the productivity of shrimp cultivation. Water quality fluctuations beyond the limits of the shrimp life tolerance range can trigger stress (Su et al 2010; Vieira-Girao et al 2015; Ariadi et al 2019) and implicitly disease, ultimately determining the decline of the cultivation productivity, due to a high mortality (Jiang et al 2005; Edhy et al 2010). Good pond water quality will play a role in the health condition and performance of cultivated shrimp (Fakhri et al 2015; Gao et al 2016), supporting a high productivity. This study aimed to determine the physical and chemical parameters of water and plankton communities of *L. vannamei* ponds run by farmers in the Mootilango Village, Duhiadaa Subdistrict, Pohuwato Regency, Gorontalo.

Material and Method

Sampling. The research was conducted at the shrimp farming center of Mootilango Village, Duhiadaa Subdistrict, Pohuwato Regency in June 2021. The data was collected using a survey method that assumes that a small percentage of the population describes the overall nature of the population under investigation (Suwignyo 1976). Water and plankton sampling was performed at five stations representing shrimp farming ponds' inlet, central and outlet areas. The location of station 1 is in the Northern pond, close to the settlement/highway (0°27'88476" LS, 121°52'77512" BT); station 2 in the West pond, close to the fish demolition pier (0°28'33193" LS, 121°52'98065" BT); station 3 on the pond in the middle of a crop of shrimp farms (0°27'4408" LS, 121°53'77029" BT); station 4 in the Eastern pond, close to the big river (0°26'65386" LS, 121°53'9363" BT) and station 5 at the Southern farm close to the sea (0°27'41956" LS, 121°53'2576" BT). The research site can be seen in Figure 1.

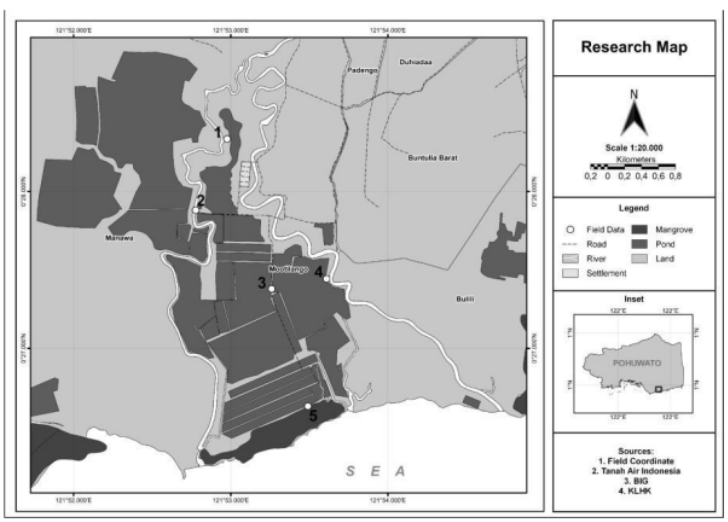

Figure 1. Map of the research location.

The sampling at each station is repeated three times. Temperature, brightness, conductivity, total suspended solids (TSS) and total dissolved solids (TDS) are the physical parameters, while pH, dissolved oxygen (DO), salinity, nitrate (NO_3), ammonia (NH_3), phosphorus (P) and biological oxygen demand (BOD) are the chemical parameters measured. In addition, plankton density, plankton diversity, dominance index and uniformity index are the plankton parameters. Water quality checker devices can measure temperature, pH, dissolved oxygen (DO), salinity and conductivity. In contrast, other water quality parameters are examined by sending water samples from each station to UPTD Regional Health Laboratory, Gorontalo Provincial Health Office.

A plankton sampling was carried out by filtering water as much as 40 L using net plankton with a mesh size of 30 μm. The filtering results of 50 mL were preserved by adding 4% formalin. The samples were then brought to the Hydrobioecology and Biometric Laboratory, Faculty of Fisheries and Marine Sciences, Gorontalo State University, to be analyzed. The plankton was counted on 1 mL of sample, using glass objects. Observation of the plankton density was carried out using the census observation method. The identification process was carried out under a 10x binocular microscope and using the plankton identification key book Davis (1955), Prescott (1970) and Toshmiko (1979).

Data analysis. The observed plankton parameters include plankton abundance, diversity, dominance and uniformity index.

Plankton abundance. The abundance of plankton was calculated using a formula of Sachlan (1982):

$$N = \frac{V_r}{V_0} \times \frac{1}{V_s} \times n$$

Where:
N - total number of individuals per liter;
V_r -Volume of filtered water with a sieve in a bucket (50 mL);
V_0 - volume of 1 drop of sample water (1 mL);
V_s - volume of water filtered with a net plankton filter (40 L);
n - total number of plankton per field of view.

Plankton diversity index. The plankton diversity index is used to determine the diversity of plankton species in the waters through the calculation of the Shannon-Wiener equation (Magurran 1988) as follows:

$$H' = -\sum_{t=1}^{s} Pi \times Ln_{Pi}$$

Where:
H' - the Shannon-Wiener diversity index;
S - number of species;
P_i - n_i N^{-1};
N_i - number of individuals of each species;
N - total number of plankton (all species).

Plankton uniformity index. The plankton uniformity index was calculated using a formula according to Arinardi et al (1996):

$$e = \frac{H'}{H^{maks}}$$

Where:
e - uniformity index;
H' - the Shanon-Wiener diversity index;
H^{maks} - Ln of the number of species.

Plankton dominance index. The Simpson dominance index was used to determine the relative abundance of certain species of plankton in the waters and is calculated using the equation of Odum (1993) as follows:

$$D = -\sum_{t=1}^{s}\left(\frac{n_i}{N}\right)^2$$

Where:
D - dominance index;
S - number of species;
N_i - number of individuals of a species;
N - total number of individuals of all plankton species.

Results and Discussion

Water quality. *L. vannamei* cultivation ponds in the Mootilango Village, Duhiadaa Subdistrict, Pohuwato Regency are still running with a traditional management system. The pond is still a soil pond and the cultivation system relies on natural feed. The state of shrimp cultivation in traditional ponds is affected by environmental factors (water quality). Survival rates, growth and shrimp reproduction can all be affected by poor water quality. Table 1 shows the concentration of each water quality parameter at the research site.

Table 1

Water quality of *Litopenaeus vannamei* farming ponds on the coast of Tomini Bay, Mootilango Village, Duhiadaa Subdistrict, Gorontalo

No	*Parameters*	*Station*				
		1	*2*	*3*	*4*	*5*
		A. Physical				
1	Temperature (°C)	31.70	34.40	34.80	34.30	34.30
2	Brightness (cm)	37.00	21.00	34.00	38.00	38.00
3	Conductivity	19.30	43.40	25.80	57.40	57.40
4	TSS (mg L^{-1})	30.45	76.37	36.82	30.94	66.43
5	TDS (mg L^{-1})	52.70	113.10	67.50	117.00	86.10
		B. Chemical				
1	pH	6.80	7.80	7.40	7.40	7.40
2	DO (mg L^{-1})	3.90	2.16	6.07	6.31	6.31
3	Salinity (mg L^{-1})	10.00	27.00	16.00	30.00	30.00
4	NO_3 (mg L^{-1})	<1.00	0.00	<1.00	0.00	0.00
5	Ammonia (mg L^{-1})	0.41	0.17	0.34	>3.00	0.20
6	P (mg L^{-1})	0.15	0.20	0.11	0.08	0.13

In shrimp farming, maintenance of a good water quality is essential to achieve an optimal shrimp production. Water exchange is a common method of reducing the accumulation of ammonia and organic matter (Boyd 2003) and of preventing a decrease in water quality (Burford et al 2003). In general, the value of pond water quality parameters in Mootilango Village is in a fairly good condition and suitable for the cultivation of *L. vannamei*. According to Edhy et al (2010), the water quality parameter values that are suitable for the cultivation of *L. vannamei* are: a brightness of 30–40 cm, a dissolved oxygen (DO) >4 mg L^{-1} and a salinity of 5–35 mg L^{-1}.

Brightness is a measure of water transparency that can reveal the presence or absence of particles suspended in the water. Brightness measurements can be visually evaluated using the Secchi disk. Romimohtarto & Juwana (2004) stated brightness is the translucent power of the sun into the water. The results showed the brightness value of the pond was in the optimal range for *L. vannamei* cultivation, except for station 2, which is a pond close to the unloading area, with a brightness value of 21.00 cm. One of the causes of low brightness levels at station 2 is the large supply of sediment and dissolved particles due to the unloading, which is then carried by the tide to the pond area.

Temperature greatly affects oxygen consumption and shrimp growth in aquaculture environments (Lu-Qing et al 2007). The water temperature at the study site ranged from 31.70–34.80°C, above the optimum temperature range that supports the *L. vannamei* cultivation (26–32°C), according to Edhy et al (2010). The high water temperatures measured at the research sites can be affected by observations made during the day and by the lack of plants or trees. Increased temperature can lead to increased decomposition of organic matter by microbes (Effendi 2003).

Total suspended solids (TSS) consist of particles that do not pass on a filter paper measuring 20 μm or insoluble in water (APHA 2005). TSS consists of mud, fine sand and trace particles, mainly caused by soil erosion, carried to the water bodies (Effendi 2003). TSS at shrimp farming ponds in Mootilango Village ranges from 30.45–76.37 mg L^{-1}. The range of TSS values is smaller when compared to the TSS range in the mooring area of Gresik Regency, East Java, which ranges from 15.0–119.0 mg L^{-1} (Pirzan & Utojo 2013).

The degree of acidity (pH) is the negative logarithm of the concentration of hydrogen ions released in water. The degree of acidity (pH) of shrimp farming ponds in Mootilango Village ranges from 6.8–7.8. Edhy et al (2010) mentioned that the range of pH values suitable for the cultivation of *L. vannamei* is 7.5–8.5. The pH value at station 1 is quite low and can endanger the lives of shrimp in ponds. Low pH of pond water at station 1 can occur due to the decomposition of organic matter by microorganisms (Supriatna et al 2020). Increasing the pH value can be done by introducing dolomite lime inside the pond (Sahrijanna & Sahabuddin 2014).

The results of DO measurements at observation stations are generally above the optimal value for supporting the life of *L. vannamei* (Edhy et al 2010). However, a fairly low DO value was found at station 2, with a value of 2.16 mg L^{-1}. This value has the potential to endanger the survival of shrimp. On the other hand, salinity also plays a role in the growth rate, amount of food consumed, value of food conversion and egg hatchability (Andrianto 2005). Although still in the range of values suitable for the cultivation of *L. vannamei*, due to the characteristics of the euryhaline species (Mustafa et al 2007b), the salinity at station 1 is quite low compared to other stations. The low salinity value at station 1 is due to the location of this station, which is adjacent to a big river and near the settlement of residents, thus obtaining a considerable supply of freshwater.

The nitrate content (NO_3) in the waters results from the oxidation of nitrites (NO_2) accumulated from shrimp waste and the decomposition of bacteria absorbed as foodstuffs by algae. NO_3 compounds are the main form of nitrogen in natural waters and play an essential role as the primary nutrient for the growth of algae and aquatic plants. The results showed that nitrate levels at stations 1 and 3 were <1.00 mg L^{-1}, while at the other three stations, they were 0.00 mg L^{-1}. According to Effendi (2003), nitrate levels of more than 0.2 mg L^{-1} can result in eutrophication or nutrient crawling in the waters, stimulating the rapid growth of algae, aquatic plants and natural feed. Meanwhile, Clifford (1998) mentioned that the optimum nitrate concentration for *L. vannamei* ranges from 0.4-0.8 mg L^{-1}. Thus, the nitrate content of shrimp farming ponds in Mootilango Village, in general, is still within the range limits that shrimp can tolerate.

Microorganisms decomposed the undigested food, feces and other organic matter into inorganic nutrients such as phosphate, ammonia and carbon dioxide (Boyd 1990). Shrimp use protein as an energy source and produce ammonia in metabolism. Ammonia accumulated in waters can be toxic to biota if the levels exceed the maximum threshold (Hamuna et al 2018). The results showed that the ammonia value in the pond waters of Mootilango Village was quite low at 0.17–3.00 mg L^{-1}. The absence of artificial feed in traditional pond management systems in Mootilango Village could explain the low ammonia content at the research site. In addition, the value also indicates that the research site still tends to be unpolluted and appropriate for supporting the growth and development of *L. vannamei*. As Effendi (2003) stated, high ammonia levels indicate the presence of organic matter pollution derived from domestic waste, industrial waste and agricultural fertilizer runoff.

The availability of phosphate (P) in waters is closely related to the phosphate content in the soil. Phosphate is a compound that plays a role in the formation of proteins and in the photosynthesis of aquatic biota (Effendi 2003). Phosphate levels in water are unstable because they are easily eroded, weathered and diluted (Hamuna et al 2018). The results showed that phosphate concentrations at research stations ranged from 0.08–0.20 mg L^{-1}. According to Anhwange et al (2012), the recommended maximum phosphate level in the waters was ≤0.1 mg L^{-1} and waters with phosphate values above were indicated as eutrophic. Nonetheless, the value derived from the observations hasn't deviated too far from the optimal phosphate range, still being in the range of values that shrimp can tolerate.

Plankton community. The results of observations of biological parameters are indicated by the values of abundance, diversity, uniformity and dominance of plankton in the waters. Plankton is a crucial constituent of the trophic structure, which forms food webs that play a critical role in the balancing of the aquatic ecosystem (McManus & Woodson 2012; Acevedo-Trejos et al 2015). Phytoplankton is a source of organic matter that acts as the basis of the food chain and determines the health of aquatic ecosystems (Nursuhayati et al 2013), while zooplankton plays an essential role in the carbon cycle and other vital elements in the waters (El-Sherbiny et al 2011). The physical-chemical characteristics of the waters have a significant impact on plankton growth. Plankton found in the *L. vannamei* farming system of Mootilango Village, Duhiadaa Subdistrict consists of 17 classes with variations in the abundance of each class, as shown in Figure 2 below.

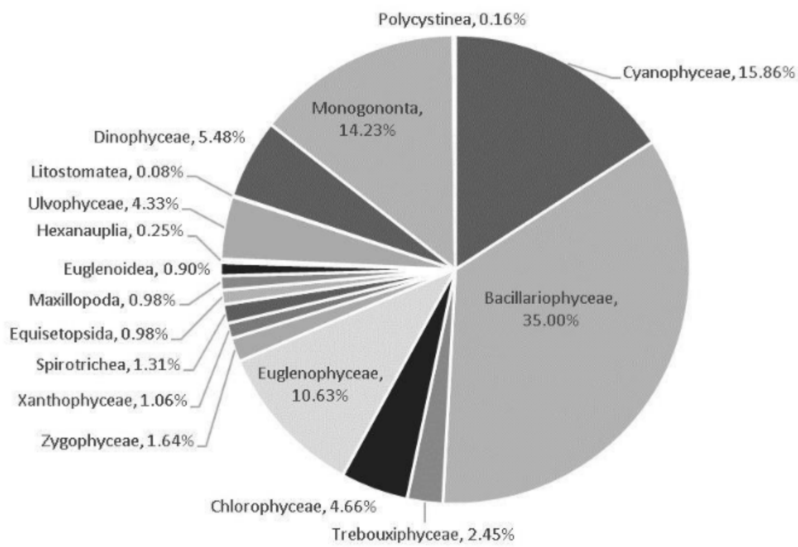

Figure 2. Abundance of plankton pond *Litopenaeus vannamei* Mootilango Village.

The results of observations obtained 17 classes with 71 genera, consisting of Bacillariophyceae (21 genera), Cyanophyceae (9 genera), Chlorophyceae (9 genera), Euglenophyceae (6 genera), Spirotricea (4 genera), Maxillopoda (4 genera), Monogononta (4 genera), Zygophyceae (3 genera), Xanthophyceae (2 genera), Euglenoidea (2 genera) and Trebouxiphyceae, Equisetopsida, Hexanauplia, Ulvophyceae, Litostomatea, Dinophyceae and Polycystinea, each containing one genera. The total plankton abundance of Mootilango Village vannamei shrimp pond is 509.579 ind L^{-1} and dominated by Bacillariophyceae class with an abundance of 178.333 ind L^{-1} (Figure 2). Other classes of plankton in considerable abundance are Cyanophyceae 80.833 ind L^{-1}, Monogononta 72.496 ind L^{-1}, and Euglenophyceae 54.167 ind L^{-1}. At the same time, the lowest abundance is in the Litostomatea class, with an abundance of 0.417 ind L^{-1}.

Plankton abundance is the individual number of plankton per volume unit of water affected by temperature, brightness and salinity (Chai et al 2016), as well by as nutrition and eutrophication (Fehling et al 2012). The high abundance of the Bacillariophyceae class strongly supports shrimp cultivation in ponds. This phytoplankton group is a preferred natural food by shrimp compared to species in other classes (Gracia & Gracia 1985). Station 4 had the highest abundance of plankton (179.579 ind L^{-1}), while station 2 had the lowest one (62.50 ind L^{-1}). Bacillariophyceae classes dominated plankton at stations 1, 2 and 5 with an abundance value of 31.250, 23.333, and 54.167 ind L^{-1}, respectively. Station 3 is dominated by Cyanophyceae class, with an abundance value of 29.583 ind L^{-1} and station 4 is dominated by Monogononta, with 69.579 ind L^{-1}. The low abundance of plankton at Station 2 could be affected by its low brightness and its high TSS value. A high TSS prevents light penetration into the water, causing photosynthesis to be interrupted and plankton abundance to decrease.

Plankton diversity is a mathematical depiction that can facilitate the analysis of information about the type and number of organisms. The plankton diversity index (H') at the study site ranged from 3.398–4.041 (Table 2). In contrast to the abundance value, station 2 had the highest diversity index of 4.041, while station 5 had the lowest one, at 3.398. According to Stirn (1981) and Basmi (2000), the value of H'>3 indicates the stability of plankton communities, in prime condition (stable). Based on the plankton diversity index (H') value, the waters of the *L. vannamei* pond in Mootilango Village are an appropriate habitat for plankton, supporting a sustainable aquaculture. Phytoplankton diversity balances the aquaculture ecosystems as well as the natural feed cultivation in ponds.

Table 2

Diversity index, dominance index and plankton uniformity index of the *Litopenaeus vannamei* ponds from the Mootilango village

No	*Station*	*Diversity index*	*Dominance index*	*Uniformity index*
1	Station 1	3.826	0.102	1.174
2	Station 2	4.041	0.087	1.200
3	Station 3	3.651	0.163	1.044
4	Station 4	3.664	0.125	1.088
5	Station 5	3.398	0.155	1.069

Dominance indicates competition utilizes resources that lead to unbalanced or depressed environmental conditions (Barange & Campos 1991). The value of the plankton dominance index (D) in the waters of the *L. vannamei* ponds from Mootilango Village ranges from 0.087–0.163 (Table 2). The highest dominance index value was found at station 3, with a value of 0.163, while the lowest dominance index was recorded at station 2, with a value of 0.087. This dominance index value indicates that no species has a high abundance in the pond waters of *L. vannamei*. According to Pirzan & Pong-Masak (2007), a dominance value close to 0 indicates that no species has a disproportionate relative abundance, compared to other species in the community structure. Based on the plankton uniformity index (e)value (1.044–1.200), the waters of the *L. vannamei* pond in Mootilango Village indicate the presence of evenly distributed biota. This value also shows that the waters are still stable and can support productive and sustainable aquaculture efforts.

Conclusions. In general, the pond waters in Mootilango Village are in fairly good condition and suitable for the cultivation of *L. vannamei*, with a value of DO >4 mg L^{-1}, a water brightness of 30–40 cm, a salinity of 5–35 mg L^{-1} and a water ammonia levels of 0.17–3.00 mg L^{-1}. The plankton diversity index (H') at the research sites ranges from 3.398–4.041, indicating that the plankton community's stability is excellent. meanwhile, the dominance index (D) ranges from 0.087–0.163 and the uniformity index (e) values (1.044–1.200) indicate that, within the structure of the community, there are no species that significantly dominate other species and the biota is evenly distribute, with a uniform density.

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Conflict of interest. The authors declare no conflict of interest.

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