# Management of Water Quality in Intensive Enlargement of Vannamei Shrimp *(Litopenaeus vannamei)* in PT. Andulang Shrimp Farm

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Abstract

*Vannamei shrimp (Litopenaeus vannamei) was one of the commodities that was very promising for aquaculture and was a prima donna because of the high international market demand so that vannamei shrimp production needs to be increased. Increasing shrimp production can be done with a high stocking density system. However, one of the drawbacks of this system was that it can reduce water quality because this system requires high feeding. Declining water quality would caused stress to the shrimps and cause diseases that cause failure in shrimp enlargement, it was necessary to manage water quality properly and appropriately. The main parameters observed in this study were stocking density, feed management and water quality monitoring. Water quality during the observation was still in the normal range of brightness, 25-90 cm, temperature ranges between 27-31.8$^0$C, pH between 67.1-8.7, salinity 19-31 ppt, dissolved oxygen between >4.03-5.60 mg/L, alkalinity ranges from 74-154 mg/L, TOM ranges from 24.8-90.0 mg/L, ammonium ranges from 0.5-5 mg/L, nitrites range between 0.5 -18 mg/L, and phosphate ranges from 0.25-18 mg/L.*

**Keyword** : *Litopenaeus vannamei*, stocking density, feed management and water quality

## Introduction

Shrimp was a commodity that has great potential to be developed and was favored by many Indonesians. Unstsayain et al. (2017) stated that the demand for shrimp was increasing and it was hoped that the availability of shrimp would be guaranteed and able to meet the needs of the community. To increase shrimp production, the cultivators perform stocking density manipulation with an intensive system. The higher the stocking density, the higher the increase in metabolic waste. The remaining feed would settle into manure at the bottom of the pond and turn into toxic compounds for shrimp due to a decrease in water quality (Wulandari, 2015). Water quality management has a very important role in the success of shrimp farming. According to Haliman and Adijaya (2005), water quality was a key factor in the success of shrimp farming. Decreasing water quality would stress the shrimp and cause disease, which often leads to failure in rearing shrimp.

Based on the importance of water quality in supporting the success of intensive vannamei shrimp cultivation, quality management was very necessary and the need for regular water quality monitoring.

## Materials and Methods

The research was conducted at PT. Andulang Shrimp Farm, Gapura District, Sumenep Regency, East Java used survey and apprenticeship methods. Prior to research on water quality management in rearing shrimp, pond preparation, media water preparation, fry distribution and feed management were carried out.

## Results and Methods

*Pond preparation*

Pond preparation includes drying the pond bottom which was carried out for 10-15 days with the help of sunlight and aims to break the life cycle of pathogenic organisms present in the pond. Andriyanto et al. (2013) stated that the preparation of the enlargement pond was drying for 7-14 days. The pond drying process can be seen in Figure 1.

Figure 1. Pond drying (Personal Documentation, 2019).

Repair of pond construction and equipment was carried out if there was damage. Repairs were carried out, such as for perforated HDPE plastics, damaged plumbing gates, rusted pinwheels, replacement of damaged ANCO bridges. After that, cleaning the ponds was carried out after 24 h from giving chlorine. Pond cleaning aimed to clean the ponds from dead microorganisms, organic matter and sludge on the bottom of the plots. The cleaning process can be seen in Figure 2.

Figure 2. Farm cleaning (Personal Documentation, 2019)

Each plot contains 16 units of windmills with a power of 1 HP with an average plot area of 2500 m$^2$ with biomass coverage for each mill of 500 kg of shrimp. Installation of the wheel was carried out by tying the wheel to the two piles using a 50 cm long rope. The windmill was arranged in a square pattern, so that the dirt at the bottom of the plot collects at the center point of the pond (central drain). This was in accordance with the opinion of Erlangga (2012), that the installation of aeratorwheels must be carried out appropriately so as to cause a current that was concentrated in the central drain area.

*Preparation of Air Media*

Water supply activities were carried out by pumping sea water as far as 600 m from the edge of the sea. Sea water used was water from the Madura Strait. The seawater procurement process can be seen in Figure 3.

Figure 3. Seawater procurement process (Personal Documentation, 2019).

Water treatment was carried out on a plot using TCCA (Trichlor Caporit Acid) at a dose of 25 ppm. The purpose of giving TCCA was to kill harmful microorganisms. Water filling was carried out on D-17 before the spreading activity was carried out. Water filling was done by using a pump. Then the deposition was carried out in the settling reservoir for 24 h, then the water was flowed to the treatment reservoir, and the water was distributed on the maintenance plot. Initial water filling up to a height of 120 cm. Water filling in the map can be seen in Figure 4.

Figure 4. Seawater filling (Personal Documentation, 2019).

Plankton growth was carried out by fertilizing used ZA (Zwavelsure Ammoniak) fertilizer at a dose of 5 ppm. ZA fertilizer was given for 2 consecutive days. The purpose of applying ZA fertilizer was to provide additional nitrogen and sulfur nutrients. This was in accordance with the opinion of Andriyanto et al. (2013), which states that fertilization was carried out to grow natural shrimp feed, such as plankton. The process of spreading ZA and bran fermentation can be seen in Figure 5.

Figure 5. Spread of ZA fertilizer (Personal Documentation, 2019)

*Spread of fry*

The fry that were stocked at PT. Andulang Shrimp Farm was fry that come from several hatcheries, such as Ayen, STP Banyuwangi, PT. Central Pertiwi Bahari Rembang, Ndaru Laut Situbondo. The fry that were stocked the first lineage (F1) fry that already had an SPF (Specific Pathogen Free) certificate to ensure the quality of the fry. The fry that were stocked were PL 9 with a length of 9-12 mm.

Selection of fry was done by looking visually and microscopically. Visual testing was done by looking at the presence or absence of vibrio bacteria on the fry, straight body shape, swimming activity against the current if the water was turned and the color was transparent. Microscopic examination includes checking the hepatopancreas, intestines, ectoparasites, necrosis, deformity, checking MGR (Muscle Gut Ratio) and bolitas. Before the stocking was done, the fry was calculated using the sampling method. The fry calculation aims to determine the number of fry in 1 bag that would be spread on the map to obtain the desired stocking density. The stocking density of the fry was carried out at F3 with an area of 2,601 $m^2$ with a total stocking density of 476,809 with a stocking density of 183/$m^2$. This was in accordance with the opinion of Amri and Kanna (2008), that the intensive stocking density of vannamei shrimp fry was > 70 ind/$m^2$. The fry calculation process can be seen in Figure 6.

Figure 6.Calculation of fry (Personal Documentation, 2019)

The fry was spread between 05.00 - 07.00 WIB, because at that time the water temperature was still low. Before spreading the fry, the temperature acclimatization was carried out for 15 minutes or until the bags become cloudy and salinity on the mapped. The process of spreading the fry can be seen in Figure 7.

Figure 7. The process of sowing fry (Personal Documentation, 2019).

*Feed Management*

The feed used at PT. Andulang Shrimp Farm was a crumble and pellet type feed produced by PT. CJ Feed Jombang with specifications that can be seen in table 1.

**Table 1. Feed specifications**

| Code | Feed type | | Nutritional content and percentage | | | | |
|---|---|---|---|---|---|---|---|
| | Shape | Size (mm) | protein | Water content | Ash | Fat | Crude fiber |
| SS-00 | Crumble | < 0,4 | 38 | 11 | 13 | 6 | 3 |
| SS-01 | Crumble | 0,4-0,8 | 38 | 11 | 13 | 6 | 3 |
| SS-02 | Crumble | 1,0-1,4 | 38 | 11 | 13 | 6 | 3 |
| SS-02P | Pellet | 1,4-2,0 | 35 | 11 | 13 | 6 | 3 |
| SS-03 | Pellet | 1,6-2,5 | 35 | 11 | 13 | 6 | 3 |

Source: Primary data (2019).

Changed the type of feed adjusted to the age of the shrimp and the achievement of the target Average Body Weight (ABW). ABW was the average weight of shrimp in one pond in a certain period obtained by periodically collecting biomass data. with the opinion of Amri and Kanna (2008), which states that to stimulate shrimp growth, the recommended protein content in vannamei shrimp feed is at least 28%, and fat content was around 5-7%. In the middle of cultivation the protein content was reduced in order to minimize the content of organic matter wasted on the plot base.

The feeding program was carried out using the blind feeding program and post-blind feeding. Blind feeding program or blind feed was used at DOC 1 - 20, which was based on the number or population of shrimp regardless of biomass sampling. This post-blind feeding program was carried out after the shrimp enter DOC 21-harvest. This program was a continuation of the blind feeding program so that the amount of feed per day at the start of the feeding program was an increase from the amount of feed from the blind feed program. Furthermore, the total feed spent from stocking to harvesting was 14,355 kg (14.3 tons).

At Blind Feeding DOC 1 feed was given 2 times a day, at DOC 2-13 feed was given 3 times a day, entering DOC 14-27 the frequency of feed was given 4 times a day. At the time of entering DOC 28 until harvest frequency of feed was increased to 5 times a day. This was in accordance with the opinion of Haliman and Adijaya (2005), which states that the frequency of feeding small shrimp was enough 2-3 times a day because they still rely on natural food. The frequency and time of feeding can be seen in Table 2.

**Table 2. Frequency of time and feeding**

| DOC | Frequency | Time (WIB) | | | | |
|---|---|---|---|---|---|---|
| | | 06.00 | 10.00 | 14.00 | 18.00 | 22.00 |
| 1 | 2x | | √ | √ | | |
| 2-13 | 3x | √ | √ | √ | | |
| 14-27 | 4x | √ | √ | √ | √ | |
| 28-harvest | 5x | √ | √ | √ | √ | √ |

Source: Primary data (2019).

Feeding was done in 2 ways, namely manually and by using an auto feeder. In the manual method, it was done when the shrimp was 1-25 days old, the weighed feed was spread evenly on the plot using a canoe. In the use of auto feeders, it was carried out when the shrimp enters the pellet type feeding period by entering the weighed feed on the automatic feeder machine and adjusting the feeding rotation as needed. The feeding process can be seen in Figure 8.

Figure 8. Feeding (Personal Documentation, 2019).

Feed control was carried out by decreasing anco, namely at DOC 10. Anco checking aimed to determine the appetite of shrimp. Anco checks were carried out half an hour after feeding. The number of anco used was 2 pieces, with a size of 70 x 70 x 10 cm. At the time after blind feeding, anco reduction was increased to 4 pieces.

*Water Quality Management*

Water quality management has an important role in the success of shrimp farming. According to Dahuri et al. (2004) stated that water quality was a key factor in the success of shrimp pond cultivation.

*Temperature*

Temperature measurements were carried out in the early morning (04.00 WIB) and at night (19.00 WIB). The dynamics of temperature can be seen in Figure 9.

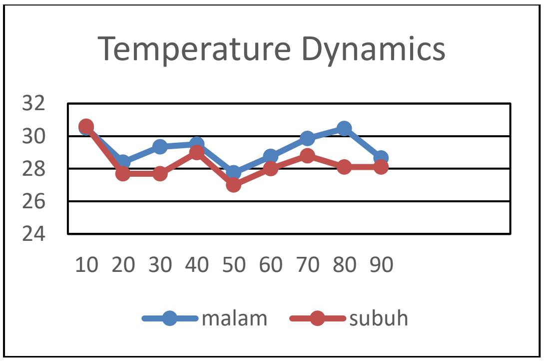



Figure 9. Graph of temperature dynamics (Primary data, 2019).

In the graph above, the temperature dynamics has increased and decreased, but it was still in the optimal range. The temperature range in the morning was 27.0-31.8 ºC with an average of 28.6 ºC and for the night it ranges from 27.5 to 31.7ºC with an average of 29.3ºC. This was in accordance with SNI 01-7246-2006, which stated that the temperature for rearing vannamei shrimp ranges from 28.5 - 31.5 ºC. The temperature decrease was due to the plankton bloom which caused the space for movement in the waters to become increasingly limited, thus disrupting shrimp growth. This was in accordance with the opinion of Maica et al. (2014), that low water temperatures tend to reduce shrimp potential. To overcome this at PT. Andulang Shrimp Farm was diluted by adding 10 cm of sea water to the plot.

*Brightness*

Brightness measurements in the morning ranged from 25-85 cm with an average of 41.4 cm and in the afternoon ranged from 30-90 cm with an average of 41.6 cm. This was in accordance with the opinion of Malik (2014), that the optimal brightness for shrimp farming was around 20-40 cm. The dynamics of the brightness measurement can be seen in Figure 10.

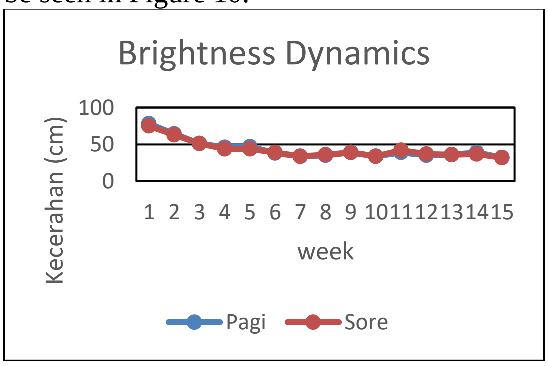


Figure 10. Graph of brightness dynamics (Primary data, 2019).

In the graph above, the dynamics of brightness at the beginning of cultivation was still relatively high, namely > 50 cm because there was not much organic material on the bottom of the pond. However, the older the shrimp, the brightness decreases, due to the presence of leftover food at the bottom of the plots and the unpopulated shrimp feces, as well as plankton blooms. In order to overcome this problem, it was carried out by filling it with water as much as 10 cm.

*Water Color*

Observations of water color were carried out in the morning and evening visually. Water color in ponds was usually dominated by plankton that live in pond waters. According to Erlangga (2012), changes in pond water color generally describe the instability of the environment in the pond. The caused of water discoloration can be seen in Table 3.

**Table 3. Water color changed**

| Warna Air | Simbol | Penyebab |
|---|---|---|
| Hijau | H | *Phytoplankton* |
| Hijau Coklat | HC | *Phytoplankton dan Diatom* |
| Coklat | C | Diatom |
| Coklat Hijau | CH | Diatom dan *Green Alga* |

*Degree of acidity (pH)*

pH measurements in the morning ranged from 7.1 to 8.6 with an average of 7.7 and in the afternoon ranged from 7.5 to 8.7 with an average of 8.0. This was in accordance with SNI 01-7246-2006, which states that the ideal water pH for rearing vannamei shrimp was 7.5-8.5. The dynamics of pH can be seen in Figure 11.

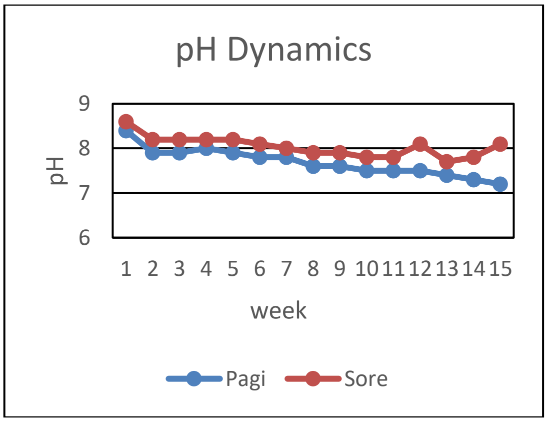



Figure 11. Graph of pH dynamics (Primary Data, 2019).

In the graph above, the dynamics of pH has increased and decreased. In the morning, the pH tends to be lower than in the afternoon because of the ongoing photosynthesis process. This was because during the daytime photosynthesis occures which causes less $CO_2$ because it was absorbed by plankton to photosynthesize and produce $O_2$ which causes the $O_2$ content to increase and causes $H^+$ ions to decrease so that water conditions become alkaline and cause pH to rise. Whereas at night there was respiration so that $CO_2$ increased and when it reacted with water ($H_2O$) it would caused the reaction to shift to the right and $H^+$ ions increase so that the water conditions would become acidic and the pH tends to be lowed. To increase the pH, liming was carried out and the pH was lowered by adding molasses. This was in accordance with the opinion of Cahyono (2011), that lime binds acidity (as a buffer).

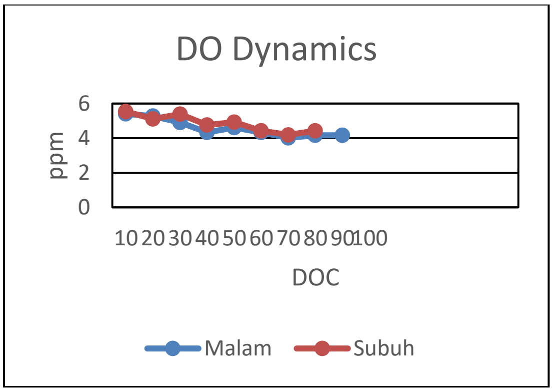



Figure 12. Dissolved oxygen dynamics graph (Primary Data, 2019).

In the graph above, DO dynamics decreased when entering DOC 40 due to increased shrimp body weight and plankton blooming, but at DOC 50 there was an increase in DO due to the addition of windmills and DO decreased again at DOC 60 due to plankton blooming and experienced an increase in DOC. 70 because of a partial harvest.

However, the range of decline was still within the optimum limit, so it has no effect on shrimp growth. This was in accordance with the opinion of Jompa et al. (2009) stated that oxygen would decrease in line with the increase in body weight of the shrimp.

*Salinity*

The results of salinity measurements ranged from 19 to 31 ppt with an average salinity of 26 ppt. This was in accordance with SNI 01 - 7246 - 2006, that the good salinity range for shrimp was 15-25 ppt. This salinity range was still well tolerated in vannamei shrimp culture. Salinity dynamics can be seen in Figure 13.

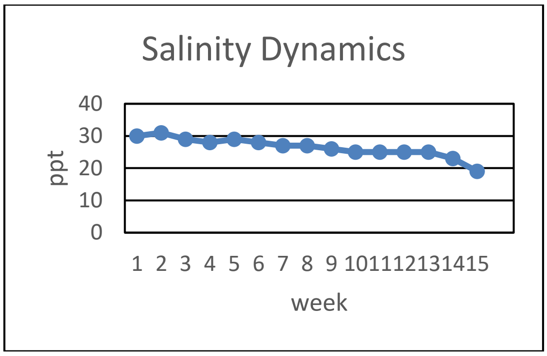



Figure 13.Graph of salinity dynamics (Primary Data, 2019).

In the graph above, the dynamics of salinity tends to decrease, this was because rainwater entered the plot so that the plot water was diluted. However, this decrease was still within the optimum limit, so that it did not interfere with the life of vannamei shrimp. This disagrees with Laramore et al. (2001), that the survival of shrimp was significantly influenced by salinity, where shrimp mortality would increase with decreasing salinity.

*Alkalinity*

Alkalinity measurement results were in the range of 74-154 mg/L with an average alkalinity of 109.84 mg/L. This was still in an optimum state because it was in accordance with SNI 01-7246-2006, that the alkalinity range for vannamei shrimp culture was 100 - 150 mg/L, can be seen in Figure 14.

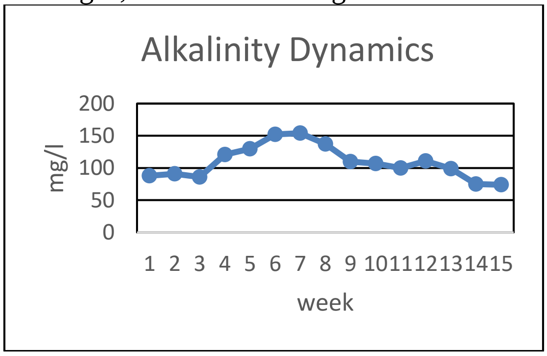



Figure 14. Graph of alkalinity dynamics (Primary Data, 2019).

In the dynamics of alkalinity, there was an increase and decrease in alkalinity due to pH instability. High alkalinity affects the shrimp, which caused the shrimp to has hard skin so that growth was difficult and if it undergoes moulting it would last a long time. Meanwhile, if the alkalinity was low, the shrimp would experience fast moulting and porousness. This was in accordance with the opinion of Kordi (2005), that the concentration of alkalinity can affect other water quality parameters, namely pH which ultimately affects production and cultivation growth. To maintain the stability of the alkalinity value, lime was added evenly and periodically to the mapped.

*Ammonium (NH4)*

Ammonium measurements obtained a range between 0.5-5 mg/L with an average of 1.93 mg/L. This result was not in accordance with the opinion of SNI 01-7246-2006, that the ammonium content was <0.01 mg/L, can be seen in Figure 15.

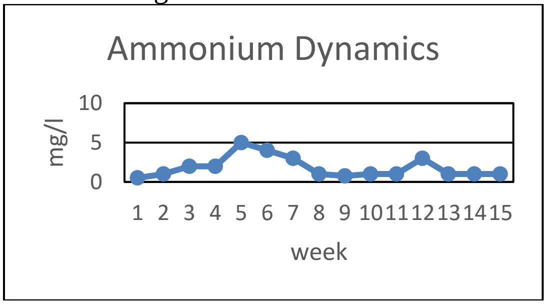



Figure 15. Graph of ammonium dynamics (Primary Data, 2019).

In the graph above, the dynamics of ammonium increased at week 5 which was caused by the large amount of leftover feed and shrimp droppings that accumulate as the amount of feed given increased. High levels of ammonium would be toxic and can result in mass mortality in shrimp. This was in accordance with the opinion of Boyd and Clay (2002), that ammonium concentrations above 4 or 5 ppm would be toxic to shrimp. To cope with the increase in ammonium, the application of probiotics was carried out directly on the plot.

*Nitrite ($NO_2$)*

From the nitrite measurement, it was found that the nitrite value ranged from 0.5-18 mg/L. With an average of 8.7 mg/L. This does not agree with SNI 01-7246-2006, that the maximum $NO_2$ content in vannamei shrimp culture was 0.01 mg/L. The dynamics of nitrite can be seen in Figure 16.

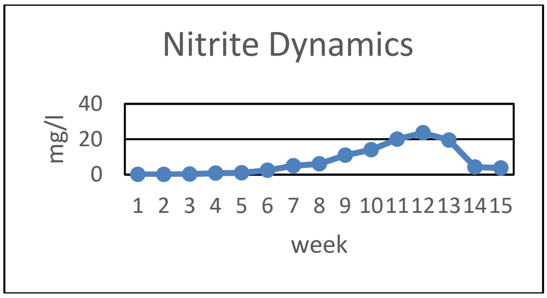
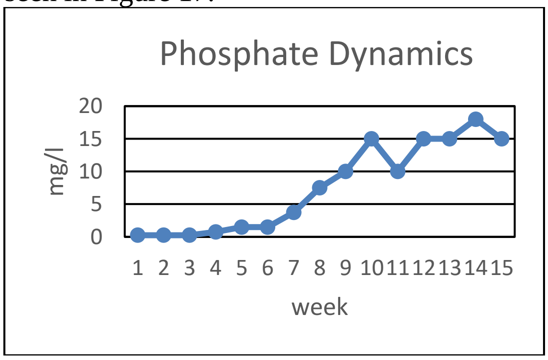



Figure 16. Graph of nitrite dynamics (Primary Data, 2019)

In the graph above, the dynamics of nitrite has increased due to the density caused by high dissolved organic matter. The increase in nitrite makes shrimp poisoning to death because nitrite was toxic by binding to oxygen in the body. This was in accordance with the opinion of Komarawidjaja (2006), that nitrite was poisonous because of its ability to bind hemoglobin so that it interferes with the absorption of oxygen in the blood. To overcome this problem, the application of probiotics was carried out and spread directly on the map.

*Phosphate (PO4)*

The results of the calculation of phosphate obtained a range between 0.5-18 mg/L and an average of 7.58 mg/L was obtained. This was in accordance with SNI 01-7246-2006, that the phosphate content in shrimp culture was at least 0.1 mg/L, can be seen in Figure 17.




*Total Organic Matter (TOM)*

TOM measurements ranged from 24.80 to 90.00 mg/L with an average of 56.57 mg/L. This did not agree with the standards of SNI 01-7246-2006, that the maximum limit for the amount of organic matter content in ponds was <55 mg/L. The dynamics of TOM can be seen in Figure 18.

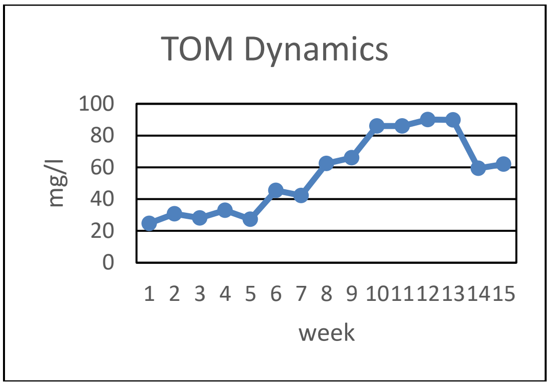



Figure 18. Graph of TOM dynamics (Primary Data, 2019).

In the graph above, the dynamics of TOM were increasing and decreasing due to the accumulation of organic matter, remaining shrimp feces and dead plankton. To overcome the high TOM, the application of probiotics was carried out which were spread directly on the map. This was in accordance with the opinion of Hartini (2014), that the process of degradation of organic matter would run well in the presence of probiotics.

*Harvest*

PT. Andulang Shrimp Farm carried out harvesting with a partial and total harvest system. Partial harvest aims to reduce biomass in the plot. Partial harvesting was carried out when the water quality has deteriorated and the tonnage has reached 4-5 tonnes. The amount of biomass extracted was 20%. Partial harvest 1 at PT. Andulang Shrimp Farm on plot F3 was carried out when the shrimp entered DOC 64. And partial harvest 2 at DOC 83. Total partial harvest of 1 F3 was ABW (average weight of sampled shrimp) 12.64 grams, size 79.10 fish with tonnage 1.07241 kg. And the total partial harvest 2 was ABW 19.03 grams, size 52.50 with a tonnage of 1.087.58 kg. The total harvest was carried out when the DOC of shrimp reached 105. The total yield was 9,129.80 kg with a size of 35.50. The total harvest was 11,288 kg with a total population of 466,665 from the stocking of 476,809 with a SR of 97.87% with a total feed during maintenance of 14,355 kg with an FCR of 1.27.

**Conclusions**

- Feed management with a blind feeding program using a feed of 462 kg and post blind feeding with a total feed of 13,893 kg with ADG 0-0.36 gr and FCR 1.27.
- Water quality management with values: Brightness (25-90 cm), temperature (27.0-

31.8 °C), DO (4.03-5.60 ppm), pH (7.1-8.7) , Salinity (19-31 ppt), Alkalinity (74-154 mg/L), TOM (24.8-90.0 mg/L), Ammonium $NH_4$ (0.5-5 mg / l), Nitrite $NO_2$ (0,5–18 mg/L), Phosphate (0.25-18 mg/L), the predominant plankton were the types of Green Algae, Diatoms, Dinoflagellates and Blue Green Algae.

- Partial yields of 1 plot F3 obtained as much as 1,072.41 kg with a size of 79.10 kg/head, partial harvest 2 obtained results of 1,087.58 with a size of 52.50 kg/head, and a total harvest of 9,129.80 kg with size 35.50 head/kg with a total of 11,289.79 kg with SR 97.87%.

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