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Implications of Good Aquaculture Practice (GAP) Application on Intensive Shrimp Ponds and The Effect on Water Quality Parameter Compatibility

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Abstract

The purpose of this study was to evaluate the suitability of water quality parameters in intensive white shrimp (*Litopenaeus vannamei*) cultivation activities based on Good Aquaculture Practice (GAP) quality standards implication practice. This research was carried out with the ex-pose facto causal design concept during one cycle of shrimp cultivation, with the indicator being studied is the condition of the water quality parameters which were then corrected with the GAP standard according to the Minister of Agriculture Regulation No. 75 of 2016. The results showed that the condition of the water quality parameters during the cultivation period was still following the GAP quality standards, except for the alkalinity parameter which had a value of 157 mg/L and organic matter 104.43 mg/L, both values were above the GAP quality standard threshold. The abnormal condition of the two parameters was caused by unpredictable natural and seasonal factors. This can be seen from the trend of the temperature and salinity parameter graphs that fluctuate unstable. Furthermore, for technical parameters, the cultivation system at the research site was still following the cultivation quality standards listed in the GAP. Based on the discussions, it can be concluded that the water quality parameters at the research pond location as a whole were still following the GAP quality standard which refers to the Minister of Fisheries Regulation No. 75 of 2016, except for the alkalinity and organic matter parameters which had a slightly worse concentration than the GAP quality standard.

INTRODUCTION

White shrimp (*L. vannamei*) cultivation is one of the most widely developed shrimp commodity activities in the aquaculture sector (Huang *et al.*, 2020). Indonesia is a tropical country, and white shrimp cultivation has been widely cultivated and developed (Ariadi *et al.*, 2020a).

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Indonesia is one of the world's largest exporters of shrimp in this decade. Vannamei shrimp cultivation in Indonesia was usually carried out in a traditional, semi-intensive, and intensive pattern (Ariadi *et al*., 2020b). The difference from this pattern lies in the level of stocking density, use of feed, cultivation technical management, and the size of the pond used for cultivation (Apud, 1985).

One of the important factors that play a major role in the success of white shrimp culture is the condition of water quality parameters (Huang *et al*., 2020). Water quality parameters are environmental indicators that play a vital role in the dynamics of the ecosystem in aquaculture waters (Ariadi *et al*., 2019b). Water quality parameters in ponds consist of physical, chemical, and biological indicators of water. Intensive shrimp farming systems greatly affect the dynamics of water quality conditions in ponds (Jayanthi *et al*., 2021). Good water quality parameters will increase the productivity of shrimp farming.

In aquaculture activities there were quality standards of GAP which can be used as a reference for aquaculture operations. GAP was a standard procedure for cultivation from pre to post-maintenance in a controlled environment (Nugroho *et al*., 2016). In GAP, quality standards were given regarding the recommended indicator threshold values in cultivation activities during the maintenance period. The application of GAP was considered very important to be applied to every cultivation activity (Sau *et al*., 2017).

One of the failures in white shrimp farming activities that were often encountered was due to poor water quality parameters. Poor water quality parameters can be caused by improper aquaculture systems or because of pollution (de los Santos *et al*., 2020). Based on the literature study above, the purpose of this research was to evaluate the suitability of water quality parameters in intensive white shrimp (*L. vannamei*) cultivation activities based on GAP quality standards.

METHODOLOGY

Place and Time

This research was conducted in 9 ponds of Cindomas Hartawi Corp. in Pandeglang Banten in April-July 2017 or during one cycle of intensive white shrimp cultivation activities.

Research Materials

pH water parameters were measured using a pH eutechecotestr™, water salinity parameters were measured using an ATAGO MASTER 53 hand refractometer, temperature and dissolved oxygen parameters were measured using a DO meter YSI550i. The brightness parameter was observed using a secchi disk, while the alkalinity and organic matter parameters were analyzed using the titrimetric method. Then the parameters of phosphate, nitrite, and ammonia were analyzed using spectrophotometry methods. Furthermore, for the parameters of total vibrio bacteria and total bacterial abundance, bacteria were planted (plating) on TCBS (Thiosulfate Citrate Bile Salt) agar media for vibrio bacteria and TSA (Tryptic Soy Agar) for total bacterial abundance, which was then incubated in an oven for 24 hours at 37 °C.

Research Design

The research was conducted in the field fact with the *ex-pose facto* causal design concept or research data collection based on real conditions in the field.

Work Procedure

The water quality parameters observed were pH, salinity, dissolved oxygen, brightness, temperature, alkalinity, phosphate, nitrite, ammonia, organic matter, total vibrio, and total bacteria. For the parameters of pH, salinity, dissolved oxygen, brightness, and temperature, measurements were taken (*sampling*) every day in the morning and afternoon, while the

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parameters of alkalinity, phosphate, nitrite, ammonia, organic matter, total vibrio, and total bacterial abundance were taken every year. Once a week at 10 am, then water samples were analyzed at the Disease and Environmental Examination Center, Minister of Fisheries Laboratory, Serang Regency.

Data Analysis

The water quality parameter data were then grouped according to the time of sampling. Then, the results were compared with the water quality standards for GAP according to Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016). The data was analyzed quantitatively by Microsoft Excel™ software.

RESULTS AND DISCUSSION

Water Quality Parameters

The value of water quality parameters from 9 ponds during one shrimp cultivation cycle on average can be seen in Table 1. Based on these data it can be stated that the overall water quality parameter values were still quite good and ideal for use as a medium for white shrimp culture. From the various parameters, the average pH value was 7.9, salinity was 32‰, dissolved oxygen was 5.56 mg/L, the temperature was 27.74 °C, brightness was 36 cm, alkalinity was 157 mg/L, organic matter was 104.43 mg/L, phosphate was 0.681 mg. /L, nitrite 0.302 mg/L, ammonia was 0.072 mg/L, total abundance of vibrio bacteria was 699 CFU/ml, and total abundance of bacteria was 214,038 CFU/ml. Good water quality parameters determine the growth rate of shrimp and the sustainability of the cultivation cycle (Hlordzi *et al*., 2020).

Table 1. Value of water quality parameters and GAP quality standards.

Parameter	Value	GAP quality standards*	Status
pH	7.9 (±0.22)	7.5-8.5	Accordance
Salinity (‰)	32 (±3.81)	26-32	Accordance
Dissolved Oxygen (mg/L)	5.56 (±0.50)	>4	Accordance
Temperature(°C)	27.74 (±0.87)	27	Accordance
Brightness(cm)	36 (±14.90)	30-50	Accordance
Alkalinity (mg/L)	157 (±14.58)	100-150	No accordance
Organic Matter (mg/L)	104.43 (±14.99)	<90	No accordance
Phosphate (mg/L)	0.681 (±0.41)	0.1-5	Accordance
Nitrite (mg/L)	0.302 (±0.26)	< 1	Accordance
Ammonia (mg/L)	0.072 (±0.06)	< 0.1	Accordance
Total abundance of vibrio bacteria (CFU/ml)	699 (±516.81)	< 1.000	Accordance
Total abundance of bacteria (CFU/ml)	214,038 (±183.98)	>10 x Total Vibrio	Accordance

*Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016).

Based on the data listed in Table 1. of all water quality parameters, only alkalinity and organic matter parameters had concentration values that didn't match the quality standards according to the Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016). The average alkalinity value during the cultivation period was 157 mg/L, while the organic matter was 104.43 mg/L. This value was above the quality standard threshold of 100-150 mg/L for the alkalinity parameter, and <90 mg/L for organic matter. Alkalinity was the value of the capacity of water to neutralize acids, or the capacity of ions to neutralize hydrogen anions in the water (Bintoro and Abidin, 2014). In aquaculture ecosystems, alkalinity functions as a buffer for changes in the pH value of the waters (Ariadi *et al*., 2021b).

Meanwhile, the concentration of organic matter which was above the water

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quality standard for shrimp farming operations, which refers to the Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016) was the most likely caused by the cultivation system used was an intensive pattern cultivation system. The intensive cultivation system allowed the accumulation of shrimp culture waste in the pond ecosystem (Páez-Osuna, 2001; Ariadi *et al*., 2019c). The concentration of organic matter in aquaculture ecosystems came from the accumulation of suspended particles, dissolved particles, and coarse particles in the pond waters. The accumulation of organic matter in pond waters would have an impact on the biochemical cycle of the water and the conditions for fluctuations in related water quality parameters (Martinez-Garcia *et al*., 2015). *Vibrio* sp. in pond waters most likely comes from the increasing load of organic material waste from shrimp farming activities (Ariadi *et al*., 2021a). In addition, high organic matter would make the oxygen concentration in the waters deflective due to the high rate of decomposition process by decomposer microorganisms (Ariadi *et al*., 2021c).

Alkalinity

The alkalinity trend value of pond waters during the intensive white shrimp cultivation season can be seen in Figure 1. The alkalinity values of 9 cultured ponds tend to fluctuate uniformly with a range of values ranging from 124-180 mg/L. The uniformity of the alkalinity concentration fluctuations was not only caused by the same water source used but also because the aquaculture operational system applied to 9 ponds was the same. Operational procedures (treatment) of cultivation would greatly affect the history of water quality parameters and the microorganism diversity in the pond (Somridhivej and Boyd, 2017). Alkalinity and hardness together were parameters that had an important effect on the level of productivity in aquatic ecosystems (Boyd *et al*., 2016).

The alkalinity value was based on the GAP standard released in the Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016) was in the range of 100-150 mg/L. An alkalinity value that tends to be low would make the pH fluctuate unstable, while an alkalinity concentration that was too high would make the water too very hard. Alkalinity has a close correlation with the value of pH, temperature, hardness, and water salinity levels (Boyd *et al*., 2011). The alkalinity value of the pond would tend to increase with the liming process, the addition of micromineral elements, and an increase in the intensity of the water temperature (Boyd *et al*., 2016). During the shrimp culture period, it was expected that the alkalinity value would always be stable to avoid a decrease and spike in pH at night and during the day (Ariadi *et al*., 2019b).

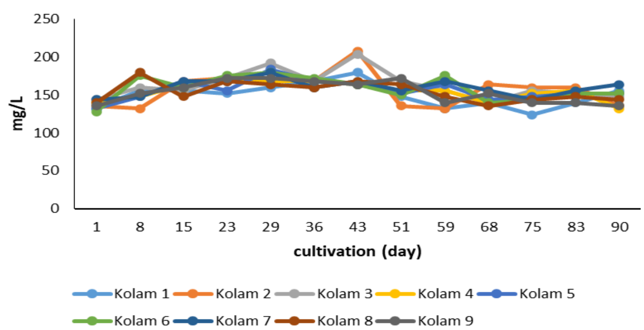

Figure 1. Pond alkalinity concentration.

Organic Matter

The level of fluctuations in organic matter concentration in pond waters dur-

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ing the vannamei shrimp cultivation period can be seen in Figure 2. During the shrimp culture period, the concentration of organic matter in 9 cultured ponds had a uniform fluctuation graph. The range of concentration values for the solubility of organic matter for 90 days was in the range from 59.35-131.96 mg/L. Based on the graph in Figure 2. it was shown that the organic matter content continues to increase and reaches its peak point at the age of 23 days of cultivation, then decreases and the concentration tends to fluctuate high. This condition was due to the first siphon activity at the age of 23 days and was carried out again every 7 days after that until before harvest. Siphon or sludge disposal in the pond sediment was the most effective way to remove organic matter and aquaculture waste (Burford and Lorenzen, 2004). The amount of waste discharged from the aquaculture pond ecosystem would minimize the occurrence of pathogenic infections due to poor environmental conditions (Khan, 2018).

The high solubility of organic matter in ponds would trigger the growth of pathogenic bacterial communities and harmful plankton communities (Ariadi *et al.*, 2019c). Pathogenic bacterial communities have fast quorum sensing capabilities if supported by water environment conditions, such as organic matter load and water temperature adapt (Ariadi, 2020). The majority of organic matter in ponds comes from feed waste and shrimp feces that had accumulated due to intensive cultivation patterns (Amirkolaie, 2011). The high content of organic matter also triggers an increase in the amount of dissolved oxygen consumption for the decomposition process (Ariadi *et al.*, 2019c). Thus, the impact of the presence of organic matter levels that exceeds the limit was that in every aquaculture pond, a partial harvesting process was always carried out, the use of a paddle wheel, and the addition of decomposer bacteria to reduce the excessive organic matter load (Ariadi *et al.*, 2020a; Wafi *et al.*, 2021a).

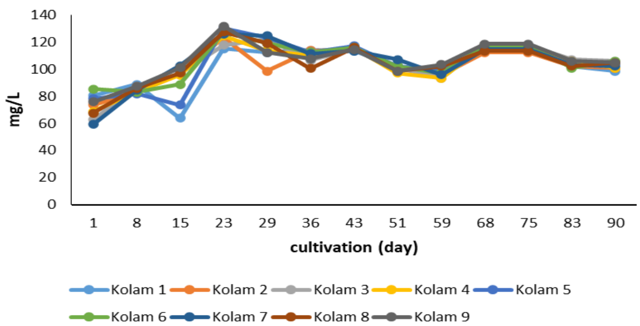

Figure 2. Pond organic matter concentration.

Salinity and Temperature

The high concentration of alkalinity and organic matter in the pond could not be separated from pond operational activities carried out during the transition season. This can be proven by the trend of water temperature and salinity rate which tend to fluctuate dynamically (Figures 3 and 4). The transition season would have the potential to affect the dynamics of aquatic ecosystems in aquaculture activities (Reid *et al.*, 2019). Temperature and salinity were environmental factors that had a major impact on the life of shrimp cultured (Páez-Osuna, 2001). Fluctuations in salinity and temperature levels would affect the level of shrimp osmoregulation in adjusting to environmental conditions (Bückle *et al.*, 2006).

The extreme range of salinity and temperature caused the shrimp easily stressed and die. Temperature fluctuation caused the solubility of oxygen in pond

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waters dynamic according to the temperature solubility trend (Wafi *et al*., 2021b). Meanwhile, the stability of salinity levels during the cultivation period would minimize the occurrence of physiological stress in the shrimp cultured (Ariadi *et al*., 2019a). As water physics factors, salinity and temperature caused an indirect influence on the solubility of alkaline ions and the decomposition rate of organic matter. Under conditions of high temperature and salinity, the solubility of alkaline ions in water and the decomposition process by bacteria would increase rapidly (Qin *et al*., 2019).

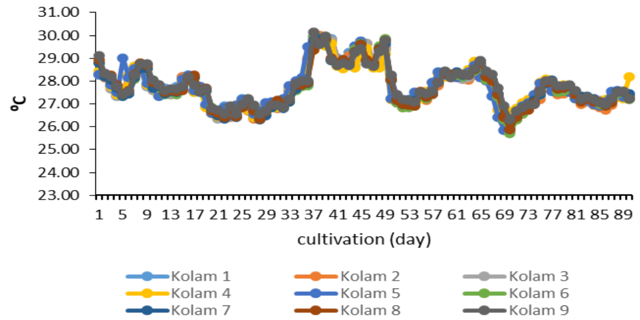

Figure 3. The graph of salinity extreme range.

In the graph of the salinity level of the pond (Figure 4), it can be seen that the first pond had different levels and trends of water salinity concentration and tends to be high compared to other ponds. This difference was due to differences in salinity levels of water sources (sea water) when filling pond water during the water preparation period (pre-stocking). Differences in salinity levels in seawater were caused by current fluctuations, extreme climate change, water intrusion, and daily circulation of water (Cullum *et al*., 2016). Salinity in marine waters could change seasonally due to climate dynamics and seasonal changes (D'Addezio *et al*., 2015).

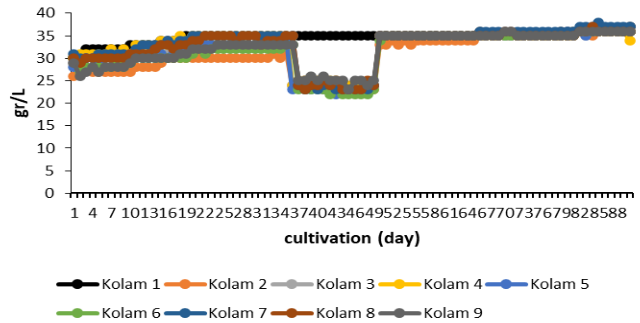

Figure 4. The graph of the salinity level during cultivation.

GAP Evaluation on Intensive Shrimp Cultivation

In this research pond, technically the application of GAP was still following the quality standards of GAP cultivation set out in the Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016). In several of the 10 GAP points, starting from pond construction, and cultivation techniques, to other supporting parameters, the ponds at the research site were under GAP quality standards. Ponds with the strict and disciplined implementation of GAP got produce optimum levels of productivity and production efficiency compared to ponds that did not use GAP cultivation standards (Yulisti *et al*., 2021).

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The application of GAP in cultivation activities was intended to create a superior and efficient cultivation system (Triyanti and Hikmah, 2015). The GAP program was a form of government policy to maintain national food security from aquaculture cultivation activities (Yulisti *et al.*, 2021). GAP was very good to be applied thoroughly by aquaculturists to form a quality national cultivation system. In addition to creating a profitable aquaculture operational standard system, GAP was also created to create a cultivation operational standard that was sustainable and environmentally friendly (Wigiani *et al.*, 2019) so it was very important for aquaculturists to pay attention to the indicators contained in the GAP quality standard, carried out direct aquaculture activities before.

Table 2. GAP evaluation on intensive shrimp cultivation.

No.	GAP of White Shrimp (*L. vannamei*)*	Condition	Status
1.	The use of paddle-wheel according to carrying capacity (1 HP/500 Kg of shrimp)	Applied the paddle-wheel with a total capacity of 16 HP for a carrying capacity 120 shrimp/m^2	Accordance
2.	Cultivation pond depth (minimum 100 cm)	Depth 100 cm of 3.200 m^2 area	Accordance
3.	Water reservoirs	Had 3 reservoirs for 9 ponds	Accordance
4.	Monitoring of water quality parameter	It was applied to control the water quality everyday	Accordance
5.	Biosecurity	Applied	Accordance
6.	The use of SPF/SPR shrimp fry category	Applied	Accordance
7.	Separate inlet and outlet design	Applied	Accordance
8.	Wastewater Treatment Plant application	Applied	Accordance
9.	The use of cultivation support facilities (gensets, water pumps, probiotics, fertilizers, etc.)	It was applied to control the cycle of shrimp culture	Accordance
10.	Feed management based on GAP quality standards	It was applied according to GAP quality standards	Accordance

*Ministerial Regulation of Marine Affairs and Fisheries Number 75 (2016).

Overall, white shrimp cultivation activities at the research site did accordance with the standards set by the GAP (Ministerial Regulation of Marine Affairs and Fisheries Number 75, 2016). The consistent and disciplined application of GAP got a technical, economic, and ecological impact on aquaculture activities (Yulisti *et al.*, 2021). This statement can be proven from the water quality profile in this study, the majority of which were above the GAP quality standard threshold. Even if there were parameters that were not under the GAP quality standards, it was more due to natural factors.

GAP standards were not a key factor in determining the success of cultivation, but GAP was one of the factors needed to obtain productive cultivation results. Based on the research results of Wigiani *et al.* (2019), the application of GAP to shrimp cultivation activities had a better business sustainability index than the aquaculture system that implemented a non-GAP system. Economically, the cultivation system with the application of GAP was considered to provide a more productive profit value compared to the non-GAP cultivation system (Triyanti and Hikmah, 2015). The problem was, GAP had not

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been implemented by all aquaculturists because of the lack of information they got. Thus, it was very important to carry out GAP dissemination activities more often in the form of research, counseling, or implementation of pilot projects.

CONCLUSION

The water quality parameters at the research pond locations as a whole were still in accordance by GAP quality standards based on Minister of Fisheries Regulation Number 75 of 2016, except the alkalinity and organic matter parameters which had a slightly worse concentration than the GAP quality standards.

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