The Effect of Water Quality Variables on Vannamei Shrimp Productivity (*Litopenaeus Vannamei*) in the Mining Area of the Sungai Pinang Village, Lingga Timur District, Lingga Regency, Riau Islands Province

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**Abstract.** Sungai Pinang Village is one of the village in East Lingga Region, Lingga Regency, Riau Islands Province, which is developing into a fisheries area. The development of the shrimp pond cultivation business is growing rapidly, but on the other hand, the quality of the waters also changes. Water quality is very influential on the growth of vannamei shrimp (*Litopenaeus vannamei*) in ponds which lead to high and low productivity of vannamei shrimp. Therefore, the research is directed at examining water quality variables that influence the productivity of vannamei shrimp in ponds. The study was carried out in an aquaculture area that was in operation in a pond in Sungai Pinang Village, East Lingga District, Lingga Regency, Riau Islands Province by interviewing respondents to obtain pond productivity primary data through a questionnaire submission, while technical data was obtained by direct measurements in the field and water sampling for analysis in the laboratory.

As independent variables are water quality, namely temperature, dissolved oxygen (DO), salinity, pH, total suspended solids (TSS), turbidity, nitrate, nitrite, phosphate and total organic matter (BOT), while the variables are not free is the productivity of vannamei shrimp. The selection of the 'best' multiple regression model is based on the backward method. The results showed that the productivity of vannamei shrimp in the range of 133.3–3,000.0 kg/ha with an average of 690.38 kg/ha. Water quality variables that have a positive effect on the productivity of vannamei shrimp are nitrate and phosphate, while the water quality variables that negatively affect the productivity of vannamei shrimp are pH and TSS.

**Keywords:** water quality, productivity, vannamei shrimp, ponds, Sungai Pinang Village

1. Introduction

The production of brackish water ponds in Sungai Pinang Village, East Lingga Sub district, Lingga Regency has decreased from 21,571.88 tons in 2017 to 14,957.59 tons in 2018. Furthermore, the decline in production is due to the occurrence of deaths when tiger shrimp aged 1–2 month, so farmers tend to switch to vannamei shrimp cultivation which is considered more promising. The transition is supported by the development of vannamei shrimp cultivation technology because the seeds are still in the SPF category, can be stocked with higher densities per hectare, and have high survival and production [1, 2], but this business is still limited to the middle class to the top. Density is commonly carried out in various regions between 80-
100 ind/m² of vannamei shrimp and can be increased up to 244 ind/m², using probiotics which are capable of producing 37.5 tons/ha cycle [2].

Ponds in Sungai Pinang Village, East Lingga Sub district, Lingga Regency have rectangular plots of form with varying per plot, inadequate irrigation networks, where most still use rainwater storage or rely on water sources from the Pinang river so that the production achieved is not proportional to the area of the pond. The area of brackish ponds in Sungai Pinang Village, East Lingga District, Lingga Regency reached 17,833.02 ha with a total production of 14,957,576 tons [3]

The productivity of the pond has a great opportunity to be improved through the application of a semi-intensive system accompanied by improvements in the design, layout, construction, and pond irrigation networks. In addition, to increase the productivity of ponds can be done with the application of lime and fertilizer (TSP, SP-36) the right start, improvement of cultivation systems, use of stocking solids in accordance with the carrying capacity of farmland, schedule of stocking is adjusted to the annual calendar (when it does not endemic disease) and maintenance time adjusted to market demand and size of shrimp.

Fishpond management is good and right, then the environment water quality of the pond is in the range that is in accordance with the growth of cultured organisms including plankton which has high diversity, the number of individuals in each species is high and evenly distributed so that the aquatic environment becomes prime which can increase pond productivity. Therefore, this study was conducted to examine the relationship between vannamei shrimp productivity from these ponds and various water quality variables in the aquaculture area of Sungai Pinang Village, East Lingga District, Lingga Regency, Riau Islands Province.

2. Materials and Methods

The study was conducted in the aquaculture area of Sungai Pinang Village, East Lingga District, Lingga Regency, Riau Islands Province. The observation station points are determined by GPS (Global Positioning System) and the distribution as shown in Figure 1. At each station, water samples are taken from farms that are in the process of maintaining vannamei shrimp. The research method applied was a survey method, including obtaining the primary data of vannamei shrimp productivity carried out by submitting a questionnaire. Variable water quality is determined by making direct measurements in the field and taking water samples for analysis in the laboratory. The measured water quality variable consists of physical and chemical variables which are considered to influence the productivity of vannamei shrimp as shown in Table 1.

![Figure 1. Research location in the aquaculture area of Sungai Pinang Village, Lingga Timur District, Lingga Regency, Riau Islands Province](image)

Water samples were taken from locations that were considered to represent the environmental conditions of pond waters and the analysis method was guided [4,5]. Descriptive statistics are used to determine the general description (minimum, maximum, average, and standard deviation) of the productivity of the vannamei shrimp and the conditions of the pond waters.
Table 1. Variable of water quality observed in the aquaculture area of Sungai Pinang Village, Lingga Timur District, Lingga Regency, Riau Islands Province

| Variable                      | Tools / methods                          | Lab / Field Analysis |
|-------------------------------|------------------------------------------|----------------------|
| **Physics**                   |                                          |                      |
| Temperature (oC)              | Thermometer                              | Field                |
| **Kimia**                     |                                          |                      |
| DO (mg/L)                     | DO-meter                                 | Field                |
| Salinity (ppt)               | Refract meter                            | Field                |
| pH                            | pH-meter                                 | Field                |
| TSS (mg/L)                   | Gravimetric                              | Field                |
| Turbidity (NTU)              | Turbid meter                             | Field                |
| NO3 (mg/L)                   | Bottle sample, cadmium reduction         | Laboratory           |
| NO2 (mg/L)                   | Bottle sample, spectrophotometer         | Laboratory           |
| PO4 (mg/L)                   | Bottle sample, ascorbic acid             | Laboratory           |
| Total Organic Materials (BOT) (mg/L) | Titrimetric                             | Laboratory           |

As the non-independent variable in this study is the productivity of vannamei shrimp, while the independent variables, namely various variables of water quality. The results of the calculation of the R-value (correlation coefficient) between the productivity of vannamei shrimp and the variable water quality are the closeness of the relationship of these variables. To calculate the effect of variable water quality on vannamei shrimp productivity, R square value is used (coefficient of determination). Tests of the corrector appropriate regression model used need to be tested for linearity relationships between the productivity of vannamei shrimp and several variables of pond water quality. In choosing the 'best' multiple regression equation, the backward method is used [6]. The significance level is set at <0.05. Data were analyzed with the help of the Statistical Product and Service Solution Program (SPSS) 15.0 (SPSS, 2006).

3. Results and Discussion

The relationship between the variables of water quality and productivity of vannamei shrimp was obtained simultaneously from the magnitude of the R-value (correlation coefficient). Based on the results of calculations, the R-value of 0.967 means that between the variables of water quality and vannamei shrimp productivity indicate a very strong level of relationship with the interpretation of the correlation coefficient between 0.80 and 1.000 (both plus and minus) [7]. The magnitude of the effect of water quality variables on the productivity of vannamei shrimp is shown by the value of R square (the coefficient terminated), which is equal to 0.935 or equal to 93.5%. In other words, the magnitude of the influence is 93.5%, meaning that the amount of productivity of vannamei shrimp that can be explained by the variable water quality is 93.5% and the rest, which is 6.5% must be explained by other causative factors originating from outside of this regression model. Thus the regression model can be predicted vannamei shrimp productivity from the equation as follows.

\[
Y = 6.547,068 - 699,257 X1 - 8,762 X2 + 1.581,470 X3 + 2.084,758 X4
\]

Where:
\[
Y = \text{Productivity of vannamei (kg/ha)}; \\
X1 = \text{pH}; \ X2 = \text{TSS (mg/L)}; \\
X3 = \text{NO3 (mg/L)}; \ X4 = \text{PO4 (mg/L)}
\]

The degree of acidity (pH) of water is important to determine the water use-value for fisheries. According [8] that generally the tolerance limits of fish and their bodies for acidity range from 4.0–11.0. Besides, pH is also related to the ability to dissolve certain compounds. The pH level of the water column fluctuates according to the photosynthetic and respiratory activities that are taking place, which starts from
low numbers at dawn to high in the middle of the afternoon [9]. The degree of acidity in this study was in the range of 8.51-9.7 with an average of 9.13 (Table 2). The pH level in vannamei shrimp cultivation appears relatively stable throughout the observation, i.e. 8.0–8.5 from the beginning of the fry stocking for up to two months of maintenance and begins to show a decline after entering the rainy season until the pH value is 7.5 [10].

Table 2. The productivity of vannamei shrimp and in water quality variables in the aquaculture area of Pinang River

| Variable               | Minimal | Maximal | Mean  | Standard deviation |
|------------------------|---------|---------|-------|--------------------|
| Productivities (kg/ha) | 133,30  | 3,000,0 | 690,38| 848,2878           |
| Temperature (°C)       | 30.31   | 33.50   | 31.47 | 1, 0374            |
| Dissolved oxygen (mg/L)| 6.98    | 7.51    | 7.30  | 0.1790             |
| Salinity (ppt)         | 0.14    | 7.36    | 1.85  | 2,6174             |
| Ph                     | 8.51    | 9.79    | 9.13  | 0.3832             |
| TSS (mg/L)             | 15      | 119     | 56.08 | 37,1670            |
| Turbidities (NTU)      | 0.85    | 86.20   | 34.66 | 26,2120            |
| Nitrate (mg/L)         | 0.1200  | 1,7224  | 0.3399| 0.4527             |
| Nitrite (mg/L)         | 0.0133  | 0.0530  | 0.0242| 0.0119             |
| Phosphate (mg/L)       | 0.0300  | 0.9945  | 0.2321| 0.2741             |
| Total organic matter (mg/L) | 11.78   | 27.56   | 19.24 | 6,1226             |

According [11], the pH value is still at a level that can be tolerated for the life of shrimp in the pond. The appropriate pH level for the cultivation of vannamei shrimp is 7.5-8.2 [1]. Previously, Choo and Tanaka (2000) reported that maintenance of tiger shrimp intensively in Malaysia with ammonia concentrations reached 0.51-1.51 mg / L in salinity 36–39 ppt, water temperature 29–32°C and pH 7–8.3. Based on the observations of the pH of vannamei shrimp, the pH that was monitored in this study was above the optimum pH for vannamei shrimp cultivation in the pond. Thus increasing the pH of one scale at a pH-meter will reduce the productivity of vannamei shrimp by 699.257 kg/ha with the provision of other fixed water quality variables.

Total suspended solids (TSS) are a non-escaping solid on filter paper measuring 20 µm or insoluble in water and only float [5]. TSS in the study locations ranged from 15.0–119.0 mg / L with an average of 56.08 mg / L (Table 2), the range is narrower when compared to the milkfish and salt ponds in East Lingga Regency, which is in the range of 4–180 mg / L [12] and in the aquaculture area of Bone District in the range 3-164 mg / L with an average of 58.88 mg / L [13]. TSS in Singkep Regency in the range of 12.0-155.0 mg / L with an average of 62.47 mg / L negatively affected the number of plankton individuals. With the variation of TSS monitored in this study, it will reduce the productivity of vannamei shrimp as much as 8.762 kg/ha with the provisions of other water quality variables not changing.

Discharges in the form of fish and shrimp droppings in the ponds and the decomposition of bacteria are absorbed as food ingredients by algae or oxidized which first becomes nitrite (NO2) then becomes nitrate (NO3) by nitrifying executing aerobic bacteria. [14] states that nitrate-N levels of more than 0.2 mg / L can result in eutrophication (enrichment of nutrients) in waters which can then stimulate the growth of algae and aquatic plants quickly including natural food. The average nitrate content in intensive shrimp cultivation with probiotic application, on the first day after shrimp in the pond, which reached 0.4367 mg / L as a result of the effect of basic fertilization carried out at the time of preparation of the pond then dropped until on the 70th day which reached an average of 0.0153 mg / L [15]. Previously the highest nitrate was 0.078 mg / L which occurred after shrimp were kept for 84 days in the pond [10]. According [16] the optimum nitrate concentration for vannamei shrimp is in the range of 0.4–0.8 mg / L. The nitrate content in this study ranged from 0.1200 to 1.7224 mg / L with an average of 0.3399 mg / L (Table 2), the average content is still lower when compared to that proposed [16], so increasing nitrate 1 mg / L will increase the productivity of vannamei shrimp by 1,581,470 kg / ha with the provision of other water quality variables.

The remaining feed, fish stools, and other organic materials are decomposed by microorganisms into inorganic nutrients: phosphate, ammonia and carbon dioxide [17]. Experience shows that fertilizing ponds with the addition of phosphate and nitrogen fertilizers will increase the production of natural feed in the pond. The addition of fertilizer will show significant phytoplankton growth in the salinity range 0–31 ppt. In maternity waters <2 ppt the growth of phytoplankton is limited by the element of phosphorus whereas in salty waters it is limited by the element of nitrogen [18].
In addition to the presence of relatively little and easily deposited phosphorus, it is also an essential element for high-level plants and algae so that this element becomes a limiting factor for high-level plants and aquatic algae that greatly affect the level of aquatic productivity [19]. The phosphate content in this study was in the range of 0.0300-0.9945 mg/L with an average of 0.2321 mg/L (Table 2). The average phosphate content in the maintenance of vannamei shrimp after 70 days continues to increase to reach 0.2733 mg/L [20].

The average phosphate content during the maintenance of vannamei shrimp in ponds is 0.5733 mg/L. The average phosphate content in this study is relatively lower when compared with the results of previous studies so that the increase in phosphate 1 mg/L will increase the productivity of vannamei shrimp by 2,084.758 kg/ha with the provisions of other variables not changing

4. Conclusion

The productivity of vannamei shrimp ranges from 133.30 to 3000.0 kg/ha with an average of 690.38 kg/ha. Water quality variables that have a positive effect on the productivity of vannamei shrimp are nitrate and phosphate, while those that negatively affect the productivity of vannamei shrimp are pH and TSS.

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