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The estimation of loading feed nutrient waste from vannamei shrimp aquaculture pond and carrying capacity of coastal area in Banyuputih sub-district Situbondo regency

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Abstract. This study aims to obtain information on feed nutrient waste originating from intensive ponds with stocking densities of 150 ind./m² and the characteristics of water bodies receiving waste loads as a reference in estimating the carrying capacity of the aquatic environment for intensive pond development in the study area. The estimation of nutrients loading was based on proximate analysis for artificial shrimp feed and shrimp carcass; nutrients retention by shrimp, a total amount of applied shrimp feed, food conversion ratio, and shrimp biomass. Nutrient loadings originating from artificial shrimp feed in 2500 m² size ponds, stocking densities of 150 ind./m² is 13.84 g TN/kg of shrimp and 8.09 gTP/kg of shrimp. Based on nutrient loadings and the volume of receiving waters, the total amount of shrimp pond that can be operated in this study area either 38 to 93 ponds with productivity 5 ton of shrimp/2500 m², respectively; to avoid environmental degradation of adjacent waters.

Keywords: nutrients loading, vanname, carrying capacity, intensive shrimp pond

INTRODUCTION

Cultivation of shrimp with intensive technology is a very productive economic activity in increasing the welfare of the community and the country's foreign exchange, but its continuity is determined by the impact of environmental damage caused [1]. Intensive shrimp farming produces high concentrations of organic and nutrient wastes sourced from the remaining feed and feces that are wasted into the waters and can significantly affect the quality of coastal waters [2]. In commercial aquaculture, 30% of the total feed given is not consumed by fish, and around 25%-30% of the feed consumed will be excreted [3]. The remaining feed and shrimp faeces are potential sources of organic matter, N, P which can affect the level of fertility (eutrophication) and the feasibility of water quality for shrimp life, as well as one aspect of determining the carrying capacity of the aquatic environment for efforts to optimize the allocation of sustainable aquaculture resources.

Utilization of coastal land for the development of intensive shrimp farming has been shown to hurt the quality of coastal waters in several countries such as Mexico [4] and Thailand[5],[6]. Therefore, to prevent the degradation of coastal waters, the development of shrimp ponds in coastal areas must pay attention to two important aspects, namely: (1) quantification of pond waste and (2) the ability of coastal waters to receive pond waste [7].

Quantification of shrimp pond waste includes the calculation of waste load generated from a shrimp farm cultivation activity, while the quantification of the ability of coastal waters is a quantitative calculation of the maximum waste load that can be accommodated by coastal waters based on assimilation capacity. The waste load data of the vaname shrimp intensive shrimp ponds in the study area and the environmental characteristics of the coastal waters of Banyuputih Subdistrict as recipients of aquaculture load can be used as a variable in determining the carrying capacity of the aquatic environment for the development of vaname shrimp cultivation in Banyuputih District, Situbondo Regency.

Carrying capacity is the maximum sustainable yield of a cultivating organism that can be produced in an area. In this study, carrying capacity is defined as the maximum biomass of shrimp that can be cultivated in ponds without violating the maximum impact that can be received by cultivated shrimp stocks and their environment. The maximum impact that can be received on aquaculture and environmental shrimp stocks is presented with pond water quality standards and the surrounding environment [8]. This study aims to obtain information on the burden of feed nutrient waste originating from intensive ponds and the characteristics of the recipient's wastewater as a reference in estimating the carrying capacity of the aquatic environment for intensive pond development.

MATERIAL AND METHODE

The study was conducted at one of the shrimp pond companies in the Banyuputih sub-district of Situbondo district in August to October 2018. Collecting data in focused on ponds the size of 2500 m² with a shrimp stocking density of 150 ind/m². Secondary data is obtained through researching some research data as well as data from agencies related to this research material.

To achieve the first goal in this study, a proximate analysis of feed samples was carried out for all types of feed used during the maintenance process as well as cultured shrimp carcasses. Proximate analysis is carried out at the Brackish Aquaculture Fisheries Center (BPBAP) in Situbondo. Data from a proximate analysis (content of N and P feed, N and P content of shrimp carcass) and Feed Conversion Ratio (FCR) were used as the basis for quantitative estimation of N and P shrimp feed waste. Estimation of Total Nitrogen (TN) and Total phosphorus (TP) waste loads, refers to the formula of Barg [9], namely:

$$LN = (A \times Cdn) - (B \times Cfn)$$

and

$$LP = (A \times Cdp) - (B \times Cfp)$$

Where:

- LN = Waste Nitrogen (kg N);
- LP = Phosphorus Waste (kg P);
- A = The dry weight of the dry pellet used (kg);
- B = The weight of the shrimp produced (kg);
- Cdn = N dry pellet content (expressed as % wet weight);
- Cdp = P content of dry pellets (expressed as % wet weight);
- Cfn = N carcass content of shrimp (expressed as % wet weight);
- Cfp = P content of shrimp carcass (excreted as % wet weight).

Furthermore, the data of intensive vaname shrimp pond waste data was used as a reference in determining the carrying capacity of coastal waters for the development of intensive vaname shrimp ponds. Estimation of the carrying capacity of intensive ponds is based on data on nutrient concentration due to the burden of pond waste that enters the receiving waters of the waste load, current nutrient concentrations, the standards of pond waste that are still allowed, and the load of nutrient waste per unit of shrimp production. Calculation of carrying capacity refers to the formula Rachmansyah et al.[2]; Nguyen et al. [10] modified:

$$DD = \frac{KL}{BL}$$

Where:

DD = Carrying capacity of waters (tons of shrimp / wide plot of ponds)

KL = Environmental Capacity in assimilating nutrient waste N and P (kg nutrient)

KL = (Allowable nutrient concentration - (current nutrient concentration + nutrient concentration from pond waste))
x volume of waste water recipient body (kg nutrient)

BL = Waste of Nutrient N and P which is released by shrimp farms (kg nutrient / ton of pond production)

The carrying capacity of the aquatic environment is presented in intensive pond land area with a stocking density of 150 ind/m² allowed to operate in coastal areas.

$$Y \square = \frac{DD}{P}$$

Where:

YT = intensive shrimp pond plots (units.);

DD = Carrying capacity (tons of shrimp)

P = Farm productivity (tons of shrimp / unit)

RESULT AND DISCUSSIONS

Production and FCR intensive shrimp ponds.

From the results of monitoring of intensive pond activities during the study, it was shown that in vaname shrimp cultivation in 2500 m² of plot area with a stocking density of 150 ind/m², during the 80 day yielded 4938 kg shrimp production with FCR (food Conversion Ratio) value of 1.49% (Table 1).

TABLE 1. Data Shrimp Production, Total Feed, FCR intensive pond (150 ind./m²)

Parameters	Pond B (Total Harvest)
Area of pond patch (m ²)	2500
Stocking density (pcs/m ²)	150
Total stocking (pcs)	3750
SR (%)	86.8
BWG (gr/pcs)	15.17
FCR (%)	1.49
Shrimp production (kg)	4938
Total feed (kg)	7358

Waste Nutrient load N and P Originated from Shrimp Feed Vaname stocking density of 150 ind./m²

The remaining feed is a key factor that influences the decline in pond water quality, while shrimp that die in ponds have a smaller effect than the rest of the feed or feces on decreasing water quality in [11]. Therefore, the remaining feed that settles at the bottom of the pond must be immediately disposed of to maintain the stability of water quality in conditions that are good for the life and growth of the shrimp that is maintained.

Feed is the main supply of nutrients in the superintensive shrimp pond system. The amount of feed used during shrimp maintenance was 7358 kg. Based on the proximate analysis of feed and vaname shrimp carcass (Table 1), it was found that the average N content of shrimp feed was 6.19% and P content was 1.61% while the content of N and P in shrimp carcasses were 7.84% and 1.59% respectively.

TABLE 2. Proximate analysis (%) of feed and vaname shrimp carcass

Parameters	Commercial Feed Shrim Type					Avarage	Shrimp carcass
	Star PLC (391)	MC (392)	BC (392)	Pellet No.1	STP FA 2P1		
Moisture	8.15	7.44	8.06	7.35	8.84	7.97	0
Ash	9.48	10.61	9.27	11.32	8.35	9.81	11.29
Crude lipid	5.43	5.87	4.99	6.92	5.93	5.83	1.52
Crude protein	42.02	37.85	37.48	35.91	36.40	37.93	49.26
Crude fibre	3.75	3.86	3.87	3.93	2.07	3.50	3.92
N	6.74	6.19	5.71	6.45	5.84	6.19	7.84
P	1.76	1.63	0.96	1.94	1.74	1.61	1.59

The waste load originating from feed contributes nutrients to the pond plots of 455.46 kg TN and 118.46 kg TP (Table 3). The difference between the number of TN and TP contained in feed and shrimp produced is the amount of TN and TP loads that enter the pond water. At the farm productivity level of 6376 kg/2500 m², the TN and TP waste loads were respectively 13.84 gTN / kg of shrimp; 8.09 gTP /kg shrimp (Table 3).

TABLE 3. Values of nutrients loading in intensif shrimp ponds aquaculture 2500 m² stocking density 150 pcs/m²

Variables	Pond area (2500 m ²) Stocking density (150 ind./m ²)
TN feed (kg TN)	455.46
Final TN of shrimp(kg TN)	387.14
Waste load TN (kg TN)	68.32
Waste load TN (g TN/kg shrimp)	13.84
TP feed (kg TP)	118.46
Final TP of shrimp(kg TP)	78.51
Waste load TP (kg TP)	39.95
Waste load TP (g TN/kg shrimp)	8.09

The increasing environmental pressure faced by the aquaculture industry requires that aquaculture activities reduce the volume of wastewater disposal and improve the quality of wastewater. The results of this study inform that there is an improvement in understanding of the intensive vaname shrimp pond waste load.

Survival values and FCR as indicators of cultivation efficiency also have the same pattern. The burden of intensive vaname shrimp ponds obtained from this study is largely determined by cultivation management strategies that are applied including pond water management, appropriate feeding strategies, and the level of shrimp production obtained.

Efforts that can be made to minimize the burden of aquaculture include: (1) increasing feed efficiency as reflected in the low-value FCR. FCR value between 1.0-1.2 is the most expected optimal value; (2) controlling feeding programs related to determining the right dosage and frequency of feeding; (3) increasing understanding of the integration between cultivation practices applied by feeding behavior and nutritional physiology of cultivated species or commodities; (4) minimizing the amount of feed that is lost or not consumed because it becomes the main source of cultivation waste through the application of automatic feeders; and (5) allocating sedimentation ponds that function as Waste Water Treatment Plants (WWTPs) so that wastewater discharge into the environment is at a permissible standard; and (6) utilizing the ecological role of aquaculture commodities such as seaweed in an integrated manner in coastal waters in an effort to minimize the potential for nutrient waste from cultivation.

Estimation of Water Carrying Capacity for the Development of Intensive Vaname Shrimp Cultivation

The estimation of the carrying capacity of intensive ponds is based on data on nutrient concentration due to pond waste loads that enter the recipient water body waste load, current nutrient concentrations, standards of pond waste that are still permitted, and a load of nutrient waste per unit of shrimp production. As a water body, the recipient of coastal water waste in Banyuputih sub-district has a water volume of 43198.298 m³ which functions to dilute waste concentration [12].

Referring to each N and P waste load and the standard for each variable N and P of pond wastewater, namely 4 ppm TN; 0.4 ppm TP is allowed, then the coastal area that can be used for intensive vaname shrimp cultivation with productivity of 5 tons ranges from 38 to 93 ponds with a size of 2500 m². The carrying capacity of coastal waters for the development of intensive ponds is determined by the level of technology applied (productivity target) related to the amount of aquaculture load, hydro-oceanographic conditions of the recipient's wastewater body, and the estimated area of impact of the water body receiving the waste load.

TABLE 4. Estimation for carrying capacity of receiving waters for super intensive vannamei development in Banyuputih District, Situbondo Regency.

Item	Value
Stocking density (ind./m ²)	150
Shrimp production (kg/2500 m ²)	4938
Food conversion ratio (%)	1.49
The water body volume that received waste load (m ³)	43198.298
Waste load TN (kg)	68.32
Estimation of the concentration of daily waste load N in waters (ppm)	0.000016
Average concentration of TN insitu 0.1307 ppm, standards effluent waste for TN allowed 4 ppm (MNRE, 2007), then the capacity of aquatic environments receiving waste water TN load (kg TN)	5647
Waste load TN (ton shrimp)	13.84
Carrying capacity per unit area (ton shrimp)	408
Ponds allowed to be operated (units)	93
Waste load TP (kg)	39.95
Estimation of the concentration of daily waste load P in waters (ppm)	0.0000092
Average concentration of TP insitu 0.0513 ppm, standards effluent waste for TP allowed 0.4 ppm (MNRE, 2007), then the capacity of aquatic environments receiving waste water TP load (kg TP)	1506
Waste load TP(ton shrimp)	8.09
Carrying capacity per unit area (ton shrimp)	186
Ponds allowed to be operated (units)	38

Environmental impact studies and hydro-oceanographic modeling and the role of the ecology of non-aquatic biotic components in minimizing cultivation waste loads, combined with the performance and cultivation technology systems developed, are expected to become a decision-making system software in determining coastal area management and development policies for sustainable intensive ponds.

CONCLUSION

A load of intensive vaname shrimp aquaculture wasted into the aquatic environment was 13.84 kgTN/ton of shrimp production and 8.09 kgTP/ton of shrimp production. Based on the P waste load variable, the development of 38-93 intensive ponds with a size of 2500 m² can be operated on an ongoing basis at a 5 ton/plot/production cycle.

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