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THE ESTIMATION OF CAPACITY OF COASTAL WATERS IN RECEIVING TOTAL SUSPENDED SOLID WASTE FROM VANNAMEI SHRIMP CULTIVATION

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ABSTRACT

This research aims to estimate Total Suspended Solid (TSS) waste from shrimp vannamei aquaculture pond and estimatation of capacity coastal waters in receiving organic waste. The results provide information that vannamei shrimp farming with stocking density (130 ind./m^2) produce TSS of 13611.63 kg TSS/ha/cultivation cycle. If all active vannamei shrimp ponds in the study area (37.8 ha) carry out the shrimp cultivation process at the same time, Total Suspended Solid (TSS) waste from vannamei shrimp pond discharged into coastal waters is 514519.43 kg TSS/ cultivation cycle. The maximum capacity of waters receiving TSS waste from shrimp ponds in the study area is 537688.09 kg TSS/day. At the current condition, TSS waste from all vannamei shrimp ponds in the study area (37.8 ha) still does not exceed maximum capacity of coastal waters in receiving TSS waste.

KEY WORDS: Vannamei shrimp pond, Total Suspended Solid (TSS), capacity coastal waters.

INTRODUCTION

Shrimp cultivation with intensive technology has been proven to have an impact on declining water quality, for example in Thailand (Hazarika *et al*., 2000, and Lorenzen *et al*., 1997), Vietnam (Bui *et al*., 2012) and Mexico (Barraza -Guardado *et al*., 2013). The main problem of shrimp cultivation with intensive technology is the waste disposal generated during the cultivation process containing organic material and high concentration nutrients as the consequence of aqua input in the aquaculture system that produces leftover feed and feces (Horowitz and Horowitz 2000, Montoya and Velasco 2000). The process of shrimp cultivation with intensive technology, 35% of feed input will be processed into organic waste in the form of Total Suspended Solid (TSS) (Primavera, 1994). That waste flows to the coast through the process of pond's water changing (Xue *et al*., 2004).

Waste entering the flowing water will be decomposed by bacteria, where oxygen is the need of bacteria to decompose the waste (Willioghby (1968), referred to in Meade (1989), Wedmeyer (1996), and Boyd (1999). The capacity of dissolved oxygen in the water for the process of decompose

organic waste is influenced by the total water volume and flushing time, which during high tide or low tide will supply oxygen.

This research aims to (1) estimate TSS waste from shimp vannamei aquaculture pond activities with fry stocking density (130 ind./m^2); and (2) estimate the waters capacity in receiving organic waste based on the amount of dissolved oxygen. The information generated from this research can be used as a reference for stakeholders for the sustainable shrimp aquaculture pond.

MATERIALS AND METHODS

This research was conducted in July to December 2017 in the area of vannamei shrimp ponds in coastal area of Banyuputih District, Situbondo Regency, East Java Province, Indonesia. Data had collected by montoring and direct measurement in the field. To achieve the first objective of this study, monitoring of vannamei shrimp cultivation was carried out in the study area. Monitoring is carried out during one cultivation cycle. Data collection was focused on shrimp feeding program and water changing in ponds area of 3100 m^2, stocking density (130 ind./m^2). The data of shrimp feeding program and water changing are used as a basis in estimating TSS refers to Widigdo and Soewardi, (2002) formula as follows:

$$Ca_n = \frac{((35\% \cdot P_1)\times 1000)}{Vtb} \quad \text{.....(1)}$$

$$Ca_{n-1} = \frac{[(Ce_{(n-1)}\times Vtb)-(35\% \times P_{(n-1)}\times 1000]}{Vtb} \quad \text{..(2)}$$

$$C_t = \sum(Q\% \times Ca_{(n-1)}) \quad \text{.....(3)}$$

In detail:

Ca_n = TSS concentration in pond plots before dilution (ppm);
Ce = TSS concentration in pond plots after dilution (ppm);
$Ca_{(n-1)}$ = TSS concentration wasted into coastal waters (ppm);
C_t = Total concentration of TSS in pond plots after dilution (ppm);
P = shrimp feeding (kg);
Vtb = water volume of pond plot (m^3);
Q% = percentage of pond water changing per day (%);
n = day 1, 2, 3, …harvest;
35%= percentage of total feed which is the burden of pond waste (Primavera, 1994).

Furthermore, to achieve the second objective of this study, data collection was carried out on the physical and chemical characteristics of coastal water. The parameters measured include: (1) the range and frequency of tides, these had taken in coastal water every hour for 15 days (15 x 24 hours) using scale board; (2) distance of shrimp pond's water intake, measured using Teodolit Nikon Series 302 and GPS; (3) waters base's slope obtained by Google Earth; (4) the length of the coastline was obtained from Sukandar *et al.,* (2016); and (5) the concentration of dissolved oxygen in the water was measured every hour for 24 hours.

Estimation of waters capacity in receiving TSS waste is based on the amount of dissolved oxygen to decompose organic waste and the amount of dissolved oxygen that need by bacteria in decomposing organic waste.

The amount of dissolved oxygen in the water to decompose organic waste is calculated using the formula of Willioghby (1968) in Meade (1989) and Boyd (1990), modified:

$$C = \left(\frac{V_{tot}}{FT} \times (O_{wb} - O_{aq})\right) \times 10^3 \quad \text{....(4)}$$

In detail:

V_{tot} = total volume of sea water (m^3);
FT = flushing time (day);
O_{wb} = the concentration of dissolved oxygen in a waterbody(ppm)
O_{aq} = concentration of dissolved oxygen needed by shrimp = 3 ppm (Boyd, 1990 dan Wedemeyer (1996);
C = The capacity of dissolved oxygen in the water to decompose organic waste (kgO_2/ day)

Total volume of sea water (V_{tot}) is calculated refers to the Widigdo dan Pariwono (2003) formula:

$$V_{tot} = (V_0 + V_S) \times F \quad \text{.. (5)}$$

$$V_0 = 0.5.h.y\left(2x - \frac{h}{tg\theta}\right) \quad \text{.. (6)}$$

$$V_s = 0.5.h.y\left(2x - \frac{2h-1}{tg\theta}\right) \quad \text{.. (7)}$$

In detail:

V_{tot} = total volume of sea water (m^3);
V_0 = volume of sea water during spring tide (m^3);
V_s = volume of sea water during neap tide (m^3);
F = tidal frequency in a day;
h = tidal range (m);
y = the length of the coastline (m);
x = distance of water intake for the pond (m);
è = underwater slope (degree).

Value offlushing time (FT) detemined by the formula:

$$FT = \frac{1}{D} \quad .. (8)$$

$$D = \frac{(V_0 - V_s)}{F \times V_0} \quad .. (9)$$

In detail:

D = dillution rate,
V_0 = the volume of sea water during spring tide (m^3);
V_s = the volume of sea water during neap tide (m^3);
F = tidal frequency in a day;
FT = flushing time (day)

The amount of dissolved oxygen that bacteria need to decompose organic waste is 0.2 kgO2/kg organic waste (Willioghby, 1968 in Meade, 1989). With reference to the statement, the amount of TSS that can be accommodated by water can be estimated by the following formula:

$$W = \frac{C}{k} \quad .. (10)$$

In detail:

C = dissolved oxygen capacity to decompose organic waste (kgO_2/day)
k = the dissolved oxygen constant needed to decompose organic waste = 0.2 kgO_2/kg waste (Willioghby, 1968 in Meade, 1989)
W = The amount of TSS waste that can be accommodated in coastal water (kg/day).

RESULTS AND DISCUSSION

Estimation TSS Waste from Vannamei Shrimp Pond

Data on the amount of shrimp feeding and the calculation TSS from vannamei shrimp ponds on Fig.1.

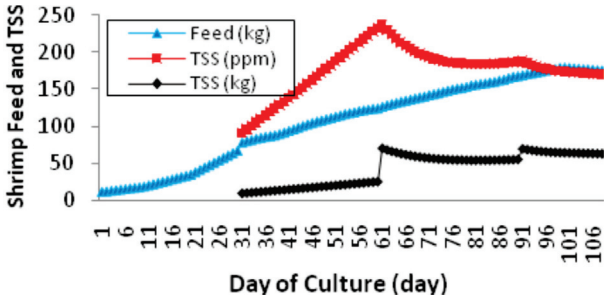

Fig. 1. Quantity of feed and TSS produced from whiteleg shrimp cultivation (130 ind./m^2), pond area (3100 m^2) during 1 cultivation cycle (day of culture 110)

TSS began to be wasted into coastal water on the day of culture 31 with 91.40 ppm concentration or the amount/weight of TSS wasted into coastal water by 10.20 kg. The highest TSS concentration of shrimp ponds wasted into coastal waters occurred on the 61st day of culture which was 237.67 ppm with the amount or weight of TSS wasted into coastal waters at 70.73 kg. The total of TSS waste from the day of culture 31 to shrimp harvest (day of culture 110) is 4219.60 kg/3100 m^2. Based on the results of the calculation, if the area of the pond (3100 m^2) is converted into a unit area of 1 hectare (ha), then the amount of TSS produced by vannamei shrimp ponds stocking density (130 ind./m^2) is 13611.63 kg TSS /ha/cultivation cycle.

Based on survey results in the field (2017), vannamei shrimp ponds that are still actively producing in the study area are 37.8 ha with an average stocking density of shrimp (130 ind./m^2), if all shrimp ponds carry out shrimp cultivation activities in the cultivation cycle, then the total of TSS waste shrimp ponds wasted into coastal water is 499561.89 kg TSS/37.8 ha/cultivation cycle.

Capacity of Waters Coast in Receiving TSS waste from Shrimp Ponds

Dissolved oxygen is needed to decompose organic waste that enters waters environment so that it will determine the ability of the waters to accommodate TSS.

The average dissolved oxygen concentration in the coastal waters of Banyuputih District in one day is 6.47 ppm. The results of measurements dissolved oxygen concentrations in coastal waters every hour for 24 hours are presented in Fig. 2. The results of calculation total sea water volume and flushing time of coastal waters can be seen in Table 1.

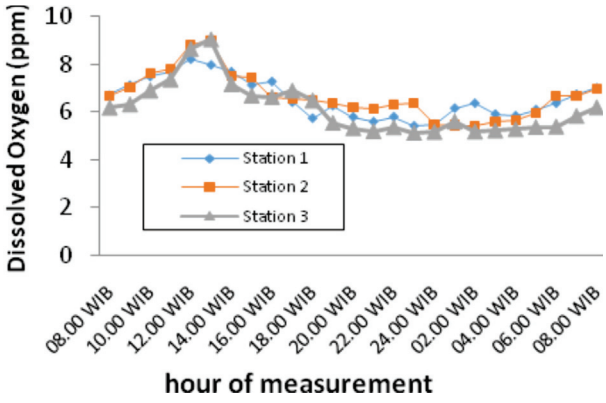

Fig. 2. Concentration of dissolved oxygen in coastal waters (24-hour measurement results).

Table 1. Physical condition of the coastal waters in Banyuputih District, Situbondo Regency.

Parameter	Value	Data Source
Tidal range at sea level during spring tide (h_{st})	0,98 m	Ground chek
Tidal range at sea level during neap tide (h_{nt})	0,32 m	Ground chek
Tidal frequency of sea water (f)	2 kali/day	Ground chek
Distance of water intake for shrimp ponds (x)	798,5 m	Ground chek
Water slope (tan è)	0,0152	Google Earth
Length of coastline (y)	46833 m	DKP in East Java Province
Concentration of dissolved oxygen(ppm)	6,47	Ground chek
Sea water volume at high tide (V_0)	35168674 m^3	Result of calculationby formula (Widigdo and Pariwono, 2003)
Sea water volume at low tide (Vs)	12144240 m^3	Result of calculationby formula (Widigdo and Pariwono, 2003)
Total volumeof sea water(V_{tot})	94625830 m^3/day	Result of calculationby formula (Widigdo and Pariwono, 2003)
Flushing Time (FT)	3 days	Result of calculationby formula (Widigdo and Pariwono, 2003)

Based on these parameters, the result of the calculation of dissolved oxygen capacity is 107537.62 kg O_2/day. The amount of dissolved oxygen that bacteria need to decompose organic waste is 0.2 kg O_2/kg organic waste (Willioghby, 1968 in Meade, 1989). Refers to the statement and the water dissolved oxygen capacity for the process of organic waste decomposition, the maximum amount of organic waste in the form of TSS that can be accommodated by the waters can be estimated is 537688,09 kg TSS/day. Currently, the total amount of TSS from all vannamei shrimp ponds in the study area (499561,89 kg TSS) still does not exceed the maximum capacity of coastal waters in receiving TSS.

CONCLUSION

TSS waste from vannamei shrimp farming activities with the stocking density 130 ind/m^2 discharged into coastal waters is 13215.92 kg TSS/ha/ cultivation cycle. If all of the active ponds in the study area (37.8 ha) conduct shrimp cultivation at the same time, TSS wasted into waters coastal is 499561.89 kg TSS/37.8 ha, and still does not exceed the maximum capacity of coastal waters in receiving TSS waste (537688.09 kg).

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