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Organic Matter Degradation in Lobster Culture System and Their Effect on Waters Quality in Ekas Bay, Indonesia

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Abstract

Feed degradation testing was carried out by feed incubation placed in nylon bags sunk in the sea for 50 days. During incubation was done the content analysis of C, N and P of feed periodicly. Waters quality determination of Ekas Bay was carried out by using STORET system. The result showed that feed decomposition rate was quickly occurred until the twenty ninth period of incubation, then continued to be slowly with the composition rate constant of

k_1 and k_2 found to be 0.043 and 0.026, respectively. Nutrient releasing (dried weight/day) of C, N and P of feed was 0.326 C/g, 0.177 N/g and 0.073 P/g, respectively. Waters quality status of Ekas Bay was in C class (moderate fouled) with standard quality over parameters were ammoniac (0.3 mg/L), nitrate (0.008 mg/L) and phosphate (0.015 mg/L). Therefore, to anticipate the availability decreasing of habitat and its effect on culture aquatic environment is need to search efforts which can decrease waste removal rate of ammoniac, nitrate and phosphate to culture environment to minimize the effect of culture activity.

Keywords: Degradation, Nutrient releasing, Feed, Water quality, Organic matter, Ekas Bay

1. Introduction

Marine culture development in Indonesia is very prospective because it is a maritime country with the coastal line length about 81000 km. The potential waters wide for marine culture is estimated ha 12.14 million. From that, it has just been used about 0.01 % (Nurdjana, 2006). One of waters areas which has the potential to be developed as marine culture is Ekas Bay, West Nusa Tenggara Province. Ekas Bay located in South part of Lombok Island has a characteristic because it directly faced with Hindia Ocean and near to Alas Straits, which connected water mass from Hindia Ocean to Pasific Ocean causing it hold more nutrient supply (Marine and Fishery Research Agency, 2004).

In Ekas Bay, Lobster culture has been developed in floating net cage since 2000. It was proved by more post larvae and larvae of lobster found to naturally stick on seaweed culture substrate and grouper (Priyambodo & Sarifin, 2009; Jones et al., 2010; Jones, 2010). In recent years, more than a hundred floating net cages have been built by the society in Ekas Bay. It indicated that floating net cage (FNC) system culture has been the economic matters prime mover of coastal society to substitute fishery capture. Therefore, it is continuously need a floating net cage culture management to support the development of Ekas Bay as aqua industry area which has a base of FNC culture.

FNC lobster culture in Ekas Bay fully has used trash fish as feed. Although trash fish has a cheaper price, it give a negative effect on culture environment namely; has the higher waste residue than formulated feed (Hansen et al., 1990; Chu, 2000, result in N loading as much as higher 17 times than formulated feed (Chu, 2000) and has the wider effect spreading (Wu*et al.,*1994). As a comparison, trash fish fed to grouper only about 82% eaten and the rest would be removed into waters environment (Noor, 2009). The accumulation of feed residue, feces and the other culture wastes will be decomposition and nutrient releasing. It is estimated 75-85% C, 40-80% N and 65-73% P which entered into culture system will be lost to aquatic environment causing water pollution and sediment (Talbot & Hole, 1994; Wu, 1995). Intensive culture and nutrient enrichment were reported to give the potential effect on water quality change (Philips et al., 1993; Boyd, 1999). The high environmental effect of culture using floating net cage system is depended on the size of floating net cage unit, fish density, floating net cage operation time period in the culture area, biophysical condition, waters oceanography, biota which lives in the culture area, and assimilation capacity of culture environment (Milewski, 2001). Besides, Chu (2000) reported that effect of the trash fish use as feed will result in N loading higher 17 times than formulated feed use.

Based on those data above, this study aims to analyze degradation rate and organic materials releasing in feed of lobster culture system and their effect on the quality of aquatic environment. This study is hoped to give the benefits in culture environment management particularly in environment fouling prevention to support the development of Ekas Bay as FNC culture-based aqua industry area.

2. Materials and Methods

2.1 Feed Degradation Testing

Feed degradation testing of trash fish was based on method described by Van Rijn and Nussinovitch (1997) and Rachmansyah (2004). Test feed was incubated by using nylon bags sink into the waters of floating net cage located in Ekas Bay (Figure 1) for 50 days. Prior to incubation, test feed was dried using oven at temperature 60 °C for 24 hours to stabilize water quality. After dried, feed was weighed to get the constant dry weight and analyzed its N, P and C content by using Kjedahl, Bray-l and Walkley Black method, respectively.

Decomposition rate and nutrient releasing observation of feed were done by using steps as followed (1) prepared 30 nylon bags with the size of 10 x 10 cm, then each bag was filled 15 g dried feed and the bags top were bound. The thirty nylon bags were entered into the net bag with the size of 60 x 30 cm and its top was also bound. (2) The net bag contained 30 nylon bags of feed was incubated into aquatic by binding to the floating net cage frame of lobster culture for 50 days. On the first fifteen days of incubation period, 3 nylon bags of samples were taken out every three-day and the next fifteen days period until on the day 50, 3 nylon bags of samples were taken out every seven-day. All taken bags were washed with fresh water, dried in oven at temperature of 105 °C for 24 hours and weighed as well as analyzed their N, P and C content.

Component in feed was consisted of labile component which can be quickly degraded and recalcitrant component which can be slowly degraded (Van Rijn et al., 1995; Van Rijn et al., 1997). By using the first orde kinetic (Avnimelech, 1984; Van Rijn et al., 1995; van Rijn et al., 1997), decomposition rate constant for the two components was determined by the equation as followed:

$$C = C_o * e^{-kt} \quad (1)$$

Note: C = Organic material concentration in t time; Co = Organic material concentration in the initial of study (t=0), and k = decomposition rate constant. Therefore, feed degradation can be described in two steps following the equation:

$$D = 100 - 100\left[S * e^{k_1 t} + (1 - S) * e^{k_2 t}\right] \quad (2)$$

Note: D = decomposition rate (% of the initial concentration); S = the initial proportion of labile material, (1-S) = the initial proportion of recalcitrant material; k_1 = decomposition rate constant for labile material and k_2 = decomposition rate constant for recalcitrant material.

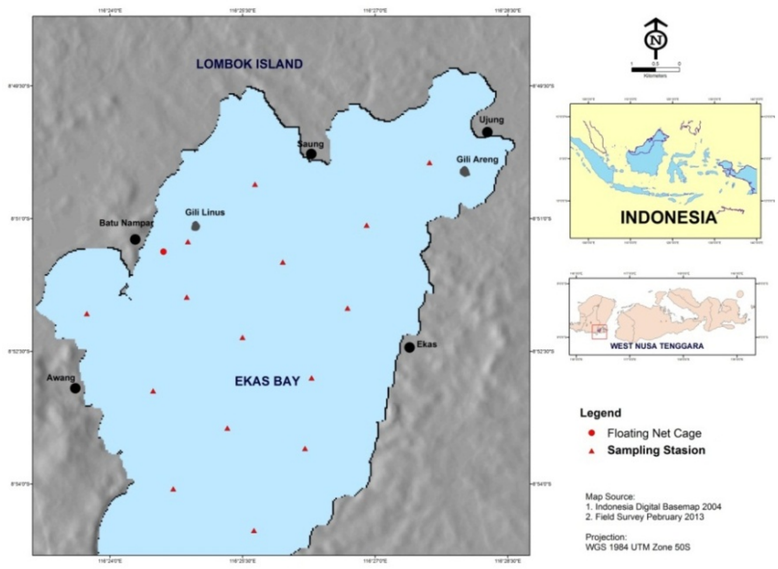

Figure 1. Study location in Ekas Bay, West Nusa Tenggara Province

Feed nutrient releasing of fish was almost similar to nutrient releasing of mangrove leaves manure namely following the equation described by Nga et al. (2004) and Mahmudi (2010) as followed:

$$NR = DW_0 * N_0 – DW_t * N_t \quad (3)$$

Note: NR = nutrient releasing ($g.g^{-1}.d^{-1}$), DW_0 = the initial dry weight of feed; DW_t = dry weight of feed rest in the t time (day), N_0 = the initial nutrient content, and N_t = nutrient content in t time

2.2 Quality Status Determination of Ekas Bay Waters

Determination of water quality was obtained through *in-situ* measurement in field and *ex-situ* in laboratory at 15 observation stations (Figure 1). Monitoring of stations was done by using GPS. Data collection was carried out by doing *in-situ* measurement in the field on water quality parameters such as temperature and dissolved oxygen, salinity, pH, and waters brightness using DO meter, refractometer, pH meter, and secchi disc, respectively. Meanwhile, ammoniac (NH_3-N), nitrate (NO_2-N) and phosphate (PO_4) were analyzed *ex-situ* in the laboratory. In this study, analysis of water quality parameters was based on APHA (1992) method.

To determine characteristic spatial spreading of water quality among stations was used fold parameter investigation approach based on Principle Component Analysis, PCA) (Soedibjo, 2008; Abdi & Williams, 2010). The final result of PCA was the presence of similarity or difference of spreading spatial parameters among observation stations. Principle component analysis used program of software XLSTAT 2013.5.09.

Status determination of Ekas Bay waters quality was done by using STOrage and RETrieval (STORET) method (http://www.epa.gov/storet/dbtop.html). STORET method principle was comparison between water quality data and water quality standard adjusted with its proposed to determine water quality status. Every observed parameter was counted its maximum, minimum and average values then, compared to quality standard value and given score. Score giving was based on Table 1. After each parameter had score value, value of the all parameters (physical, chemical and biological) was counted and compared to water quality classification based on United States Environmental Protection Agency (US-EPA) as followed: A class (very good), if score = 0, B class (good), if score = -1 to -10), C class (moderate), if score = -11 to -21, and D class (bad), if score = >-31.

Table 1. Value system determination to measure water quality status

Sample number	Value	Parameter		
		Physical	Chemical	Biological
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Source: Ministry of Live Environment (2003).

3. Results and Discussions

3.1 Feed Degradation

Feed degradation incubated for 50 days in sea waters with salinity of 32-34 ppt and temperature of 29-30 °C followed logarithmic model (Figure 2). Based on the first orde kinetic model as in the equation (1) was found that decomposition rate constant (k) was obtained to quickly decrease in the initial and slowly decrease in the end of incubation period time. It proved that feed had labile components causing the occurrence of quick degradation and recalcitrant components which were slowly degraded (van Rijn et al., 1995; van Rijn et al.,1997). Labile components degradation in feed was occurred until the twenty ninth of incubation period time, then, continued to slowly decrease (Figure 2). By using the equation (1) and (2), it was obtained $k_1 = 0.043$; $k_2 = 0.026$; $S = 0.713$, and $(1\text{-}S) = 0.287$.

The using of intensive fish culture system in floating net cage has been definite to result in waste of organic materials and nutrients, which were come from undigested feed residue, excretion and feces production (Wu, 1995; Yokoyama et al., 2010). Culture waste entering into aquatic in solid and colloid form was suspension and dissolved (Islam, 2005). Commonly, waste in solid form will precipitate to waters base whilst, the other forms will be in water's hull. If the presence of culture waste is not used by the other aquatic biota, it will be used by microbes. The use and decomposition of organic materials by microbes can be occurred in aerobic and anaerobic condition (Hopkinson Jr., et al., 2002; Mudryk & Skorczewski, 2006). Rate constant of aerobic decomposition by using the first orde kinetic in fish culture system was ranged from 0.075 to 0.15/day (Boyd, 1973; Avnimelech et al., 1995).

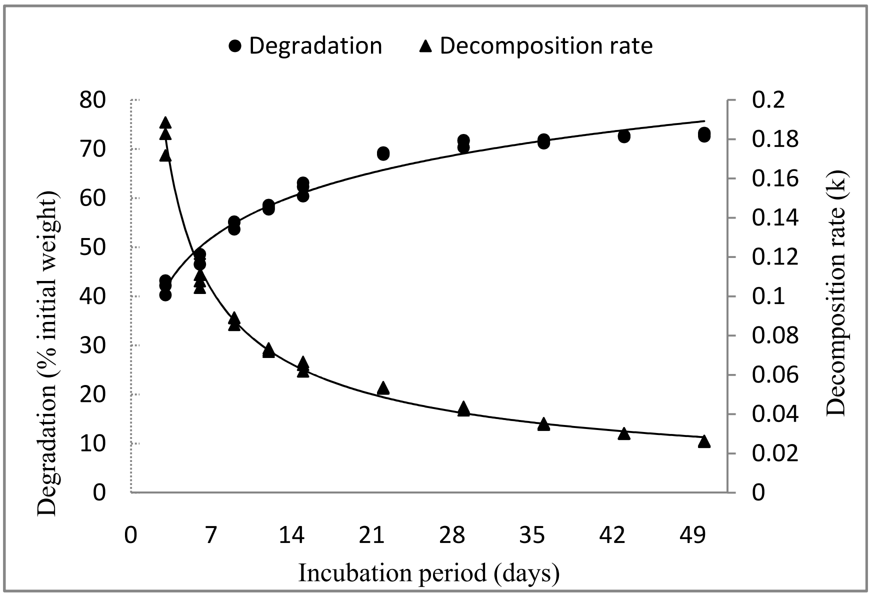

Figure 2. Degradation and decomposition rate constant of trash fish feed incubated for 50 days in Ekas Bay waters with the salinity of 32-34 ppt and temperature of 29-30 °C

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During degradation process, feed incubated for 50 days in sea waters had the decreasing C, N and P content in which up to the fiftieth day of incubation period time, the content of C, N and P was 39%, 13% and 50%, respectively (Figure 3). It indicated that during incubation, feed component quickly dispersed was Nitrogen (N) content, followed by carbon (C) and phosphate (P).

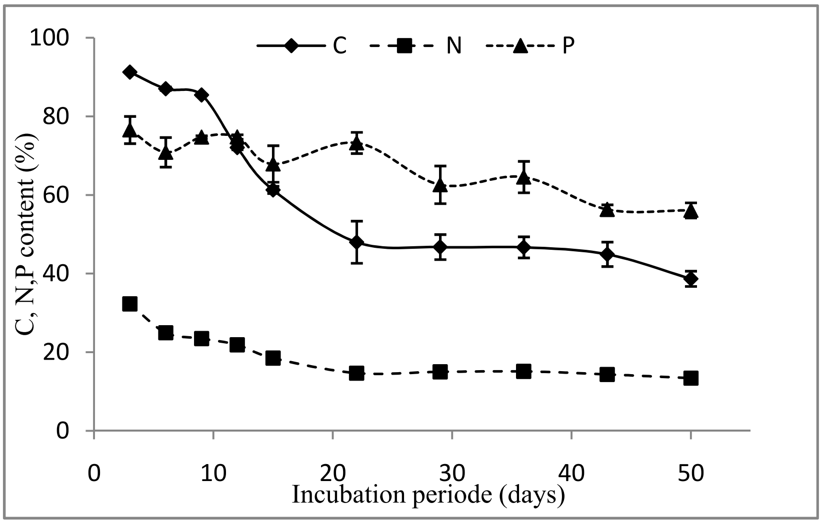

Figure 3. C, N and P content of trash fish feed incubated for 50 days during decomposition process at the salinity of 32-34 ppt and temperature of 29-30 °C

3.2 Feed Nutrient Releasing

Based on the Equation (3), it was found feed nutrient releasing incubated for 50 days in sea waters at the salinity of 32-34 ppt and temperature of 32-34 °C were 0.326 g C/g, 0.177 g N/g and 0.073 g P/g of dried feed weight per day, respectively. To determine the relation pattern between nutrient releasing and incubation time was done the regression analysis with determination coefficient estimation parameter (R^2). Regression analysis result showed that regression line of relation between feed nutrient releasing (C, N and P) and incubation time was all the three nutrients following logarithm model (Figure 4).

Culture waste load removed into waters hull gave organic material contribution causingnutrient enrichment (hypernutrification) and the organic material which influencedeutrofication and waterquality suitability on culture fish life. Previously, intensive culture and nutrient enrichment were reported to result in potential effect on water quality change (Philips et al., 1993; Boyd, 1999; Alongi, 2003; Alongi, 2009). Therefore, to determine the influence of culture waste load particularly feed residue removed into waters hull, the analysis of Ekas Bay waters quality was carried out.

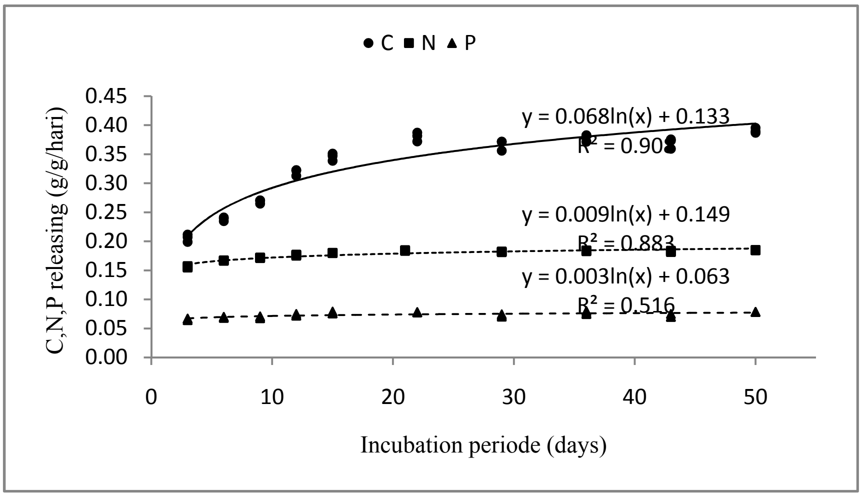

Figure 4. C, N and P releasing of trash fish feed incubated for 50 days at the salinity of 32-34 ppt and temperature of 29-30 °C

3.3 Water Quality Status of Ekas Bay Waters

Based on PCA analysis, variety of water quality parameter on the main axis the first, the second, the third and the fourth was83.03%. It means that 83.03% of analysis results data can be explained until the fourth main axis. Nevertheless, only the first (F1) and the second main component (F2) were used in the analysis interpretation. On the first axis, DO and ammoniac parameters gave the big contribution to forming of the first main axis. Temperature, ammoniac, DO, and salinity parameters showed negative correlation to nitrate, phosphate, pH, and nitrite parameters. In addition, temperature, nitrate and pH parameters had the big contribution on the forming of the second main axis(Figure 5a). Spreading of observation station on the first (F1) and the second (F2) axis (Figure 5b) displayed that every station spread evenly. It was due to the difference of water quality parameter identifier.

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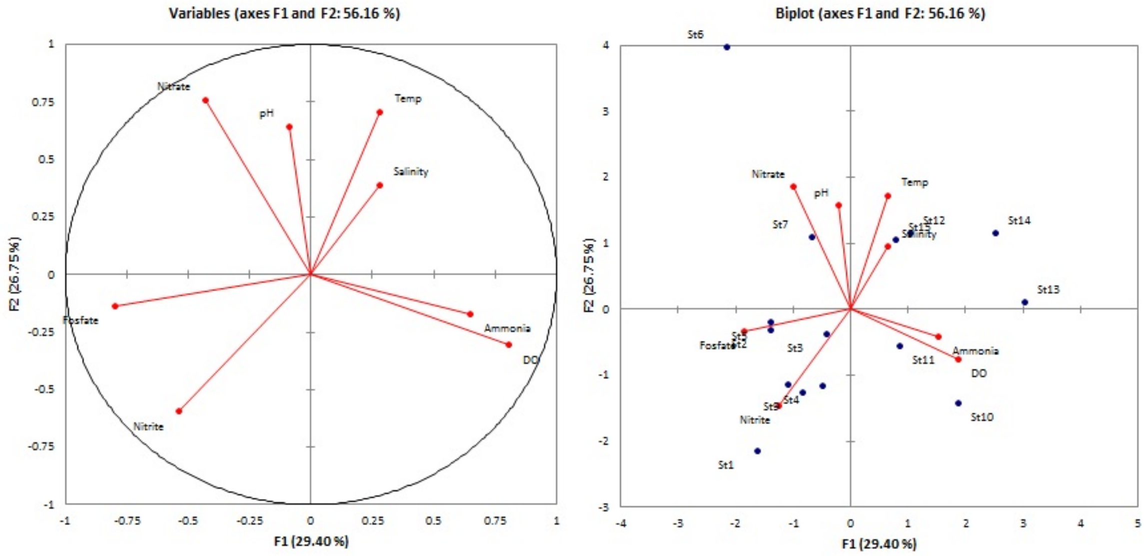

Figure 5. PCA of water quality in Ekas Bay: (a) Ordination of water quality parameter and(b) ordination of observation station

Physical and chemical parameters observation result and waters quality status determination with STORET method are list in Table 2. From Table 2, it was obtained score of -26. Based on value system of US-EPA, quality status of Ekas Bay waters was in C class (moderate fouled). Water quality parameterswith standard quality over parameters were ammoniac (0.3 mg/L), nitrate (0.008 mg/L) and phosphate (0.015 mg/L). The similar results were also reported by Krisanti and Imran (2006). Due to the concentration of ammoniac and nitrate which was over quality standard, there was no supporting to develop culture activity in Ekas Bay. Nevertheless, observation on waters fertility level showed that Ekas Bay has not been characterized as fertile waters and will cause the occurrence of plankton blooming or has not been reached waters condition lacking of oxygen. It means that there can be still developedfishery culture activity by using responsible and continuous culture method.

To anticipate the decreasing of habitat suitability and its effect on culture aquatic environment, it needs to search the efforts which can decrease waste removing to culture environment. It is done to minimize the effect of culture activity in Ekas Bay waters.Efforts which can be carried out to decrease fish culture waste load in waters are (1)arrangement by restriction of trash fish feed use, (2) feed efficiency through a good feed giving technique (frequency and appropriate feed dosage) to decrease uneaten feed residue and (3) the use and selection of feed raw material with the high digestible level.

Table 2. Quality status determination of Ekas Bay water with STORET method

No	Parameter	Unit	Qualitystandard*)	Result			Score
				Maxi-mum	Mini-mum	Average	
	Physical						
1	Temperature	(°C)	Natural	32.6	29.6	31.2	0
2	Brightness	M	>3	14.3	3	6.6	0
	Chemical						
3	Salinity	o/oo	Natural	35	34	34.9	0
4	DO	mg/l	>5	9.8	8	9.2	0
5	pH		7-8.5	8.21	7.89	8.07	0
6	Ammoniac, NH_3-N	mg/l	0.3	0.484	0.283	0.344	-8
7	Nitrite, NO_2-N	mg/l		0.1	0	0.042	
8	Nitrate, NO_3-N	mg/l	0.008	4.1	0.4	1.573	-10
9	Phosphate, PO_4	mg/l	0.015	0.42	0	0.221	-8
	Score total						-26

Note : *) Environment minister decision no. 51 2004.

The other strategies which need to be applied in continuous marine culture development in Ekas Bay waters arethe development of integrated marine farming andallocating of culture resource as well as aquainput in suitable location and no overwater environment supporting ability. These efforts are hoped to be able to give the opportunity on culture business continuity. Therefore, carrying capacity of physical, production, social, and ecological must be determined in the development of floating net cage culture based aqua industry.

4. Conclussions

Feed degradation was quickly occurred until the twenty ninth incubation period thereafter, continued to decrease slowly with decomposition rate constant, $k_1 = 0.043$ and $k_2 = 0.026$. Feed nutrient releasingof C, N and P was 0.326 g C/g, 0.177 g N/g and 0.073 g P/g of dried feed weight per day, respectively. Quality status of Ekas Bay waters was in C class (moderate fouled), in which ammoniac, nitrate and phosphate were found to be parameters over quality standard with the dosage of 0.3 mg/l, 0.008mg/l) and 0.015mg/l.To anticipate the decrease of habitat suitability and its effect on culture waters environment is need to search efforts which are able to decrease waste removing rate of feed C, N and P to culture environment. These efforts is hoped to be able to minimize culture activity effect in Ekas Bay waters.

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