IMPROVEMENT QUALITY OF BRACKISH WATERS THROUGH SEAWEED SCENARIO MODEL OF *GRACILARIA* SP AS BIOFILTER AGENT

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ABSTRACT

Development of aquaculture, especially shrimp brackish in coastal areas will greatly affect the quality of the coastal environment. Mistakes in the management of shrimp culture will lead to a decrease in environmental quality that will threaten the sustainability of coastal resources and ultimately endanger the continuity of cultivation. Decreasing the feasibility of aquatic quality as a result of disposal of cultivated waste operations can affect the life of shrimp that is cultivated can even lead to crop failure and declining productivity function of cultivated land. This research was conducted in coastal area of Brebes Sub-district, Brebes Regency. The method used in the research is direct survey in the field to obtain primary data. The results of this study showed that the presence of seaweed biofilter showed an increase in water conditions and ponds located in coastal areas of Brebes. Seaweed biofilter gives the result of absorption of Nitrogen (N) content of 0.08%, phosphorus content of 0.01% and organic C content absorbed in seaweed by 0.07%. Improving the quality of pond waters with the existence of seaweed cultivation makes a difference the organic matter content of elements of N and P compared with those not planted with seaweed. It can be seen from organic matter content, N and P is 112,72% for organic material, 0,34% for N and P equal to 0,02% for brackhishs planted with seaweed, while in brackhish not planted with seaweed material organic content of 106.20%, 0.32% for Nitrogen and 0.01% for P. During the study of water quality included in the category appropriate for aquaculture. Simulation results and model scenarios with increasing biofilter coefficients show significant rates of cultivation waste reduction accompanied by an increase in farmer's income.

Key word : model, water quality, biofilter, pattern of brackish water development

INTRODUCTION

Decreasing the feasibility of waters quality as a result of disposal of cultivated waste operations can affect the life of shrimp that is cultivated may even causing harvest failure and declining productivity function of cultivated

land. Integrated cultivation system between fish and seaweed is expected to improve the feasibility of land for coastal cultivation, as it can reduce the risk of damage to waters quality and nutrients that loose into the environment.

The purpose of this study is to determine the effectiveness and role of seaweed bio-filter (*Gracilaria* sp.) in the absorption of waste (N, P) of aquaculture brackish. The research was carried out in aquaculture of Muarareja Village, Sub district West Tegal, City and Randusanga Wetan Village, Sub district East Brebes, Brebes District in March-July 2015.

RESEARCH METHODS

The data used in this study are primary data was obtained by observative and secondary data. The research data consisted of the growth of seaweed and tiger shrimp, parameter physics-chemical water culture media, and the rate of biodegradation of brackish waste (N, P and C). Research data processing started by basic assumption test in the form of Liliefors normality test, Bartlett homogeneity test and Tukey additive test. The difference of treatment result is known by variance analysis to the extent of the difference between treatment outcomes known through the smallest real difference test.

Optimization model is done by using the system approach (dynamic system) in determining the waste load, the carrying capacity and optimization of the allocation of fishery aquaculture resources. The dynamic model structure to be constructed from seaweed brackish model started from input, process, output and feedback. Dynamic models work based on dynamic time changes.

The dynamic system model in this study is used to determine the optimal land utilization allocation for sustainable brackish development. The model to be built is arranged based on several sub models that affect the development of coastal cultivation. The sub models include: shrimp biomass sub model, sub model of seaweed biomass, sub model of aquaculture (without and with the role of seaweed bio-filter), sub model of absorption rate of waste brackish by seaweed *Gracilaria* sp. as well as sub models of environmental carrying capacity.

Data analysis method was done by dynamic system approach using Powersim studio 2005 Enterprise software aid. The operational phase was done by referring to Yusuf (2016) in Sutaman (2017) that is (1) make causal loop diagram which is a reciprocal relationship (2) Creating a flow diagram representing the reciprocal relationship of existing structures in the form of stock (level), flow, auxiliary, constant and information link, (3) creating a mathematical equation by defining the variables that will be used in mathematical units (4) Conducting simulations in the period 2015 to 2035. (5) Conduct a validation model that includes the validation of the structure and

performance validation. Structural validation is done through a consistency check model with descriptive knowledge of the systems involved in the modeling process. Performance validation is performed using the recommended statistical methods to see conformance to actual performance (factual) using MAPE (Mean Absolute Percentage Error) test.

$$MAPE = \frac{1}{n} \sum \frac{X_m - X_d}{X_d} \times 100\%$$

Where:
Xm = Data of simulation result,
Xd = Actual data
n = Number of data

The MAPE value is very accurate describing the real condition if the MAPE value is <5%. MAPE values ranging from 5% to 10% included in the category are sufficiently accurate to describe the real condition and the MAPE value> 10% then fall into the inappropriate category in describing the real condition (Morecroft, 2007)

RESULT AND DISCUSSION
1. Seaweed *Gracilaria* sp. growth
The growth of *Gracilaria* sp during the study presented in Table 1.
Table 1. Growth of Biomass Grass (Gram) Seaweed (*Gracilaria verrucosa*) with Solid Different Stocks

Treatments	Repetitions	Wo	Wt, Sampling / Week				
			I - II	III – IV	V - VI	VII-VIII	IX – X
A	1	60	70.15	84.37	116.20	133.40	149.70
0,06	2	60	68.70	85.20	114.73	129.35	144.92
gram/m²	3	60	67.95	83.76	112.85	128.87	134.42
Different, Average	+ 83,01	60	68.93	84.44	114.59	130.54	143.01
B	1	120	128.93	142.30	159.06	180.27	194.73
0,12	2	120	126.38	140.47	156.32	175.99	184.50
gram/m²	3	120	127.50	146.58	164.20	184.72	217.50
Different, Average	+ 78,91	120	127.60	143.12	159.86	180.33	198.91
C	1	180	197.30	220.10	248.71	286.02	300.10

0,18 gram/m²	2	180	190.45	217.68	234.45	252.17	271.40
	3	180	199.15	223.26	252.28	290.13	320.15
Different, Average	+ 117,22	180	195.63	220.35	245.15	276.11	297.22
D 0,24 gram/m²	1	240	249.60	262.08	270.86	284.40	296.20
	2	240	248.92	261.37	274.43	288.16	304.75
	3	240	251.26	265.78	279.07	293.02	337.50
Different, Average	+ 72,82	240	249.93	262.42	274.79	288.53	312.82
E 0,30 gram/m²	1	300	309.00	317.69	325.48	334.58	342.97
	2	300	313.20	318.25	328.14	340.12	338.40
	3	300	311.26	323.71	334.67	342.80	357.80
Different, Average	+ 46,39	300	311.15	319.88	329.43	339.17	346.39

Gracilaria verrucosa biomass weight growth data are normal, homogeneous and additive and differ significantly between different density. The result of BNT test of G. verrucosa biomass weight growth is presented in Table 2.

Table 2. BNT Test Results Growth of Absolute Weight *Gracilaria* sp.

Density (gram/m²)	Average	Difference with density (gram/m²)			
		0,18	0,06	0,12	0,24
C : 0,18	117.22				
A : 0,06	83.01	34.21*			
B : 0,12	78.91	38.31*	4.10		
D : 0,24	72.82	44.40*	10.19	6.09	
E : 0,30	46.39	70.83**	36.62*	32.52*	26.43

  * = significantly different (P<0,05)
  ** = very significantly different (P<0,01)

G. verrucosa with density 0.18 g / m2 (treatment C) has the best biomass growth than other treatments.

2. Growth of Windu Shrimp (*Penaeus monodon Fab.*)

Increasing of individual weights of tiger shrimp during the study presented in Table 3.

Table 3. Growth individual weight shrimp windu during the study

Treatments	Repetitions	Wo	Wt, Sampling / Week (gram)				
			I-II	III-IV	V-VI	VII-VIII	IX-X
0,00 gram/m²	1	2.55	6.41	11.16	16.39	16.85	21.95
	2	2.86	6.57	10.87	17.02	20.37	24.40

	3	2.99	6.34	10.96	14.81	18.94	23.36
Different, Average	+ 20,44	2.80	6.44	11.00	16.07	18.72	23.24
0,06 gram/m^2	1	2.12	5.66	10.51	13.76	16.58	21.45
	2	2.61	6.00	10.95	17.24	19.63	25.57
	3	2.72	6.94	11.61	17.00	22.43	26.72
Different, Average	+ 22,85	2.38	6.20	11.02	16.00	19.55	25.23
0,12 gram/m^2	1	2.11	5.89	10.60	14.69	19.43	24.95
	2	2.65	6.88	11.63	17.96	20.43	26.94
	3	2.88	7.52	12.11	18.85	24.52	31.10
Different, Average	+ 25,11	2.55	6.76	11.45	17.17	21.46	27.66
0,18 gram/m^2	1	2.09	6.31	11.42	18.30	23.04	28.96
	2	2.67	7.98	12.85	18.77	23.67	30.26
	3	2.83	8.31	12.94	18.87	21.48	27.35
Different, Average	+ 26,33	2.53	7.53	12.40	18.65	22.73	28.86
0,24 gram/m^2	1	2.60	7.35	12.14	18.56	20.84	26.96
	2	2.89	8.44	12.79	18.41	23.56	31.89
	3	2.95	8.71	13.25	19.33	26.58	31.17
Different, Average	+ 25,86	2.81	8.17	12.73	18.77	23.66	28.67
0,30 gram/m^2	1	2.40	6.61	11.32	16.94	22.25	27.58
	2	2.76	7.82	12.00	17.61	23.87	31.06
	3	2.86	7.79	11.87	17.79	20.87	27.30
Different, Average	+ 25,98	2.67	7.41	12.73	17.45	22.33	28.65

The growth data of individual weights of tiger shrimp are normal, homogeneous and additive and have significant differences between treatments. BNT test results presented in Table 4.

Table 4. BNT test result of individual weights of tiger shrimp

Treatments	Average	Difference with density (gram/m^2)				
		0,18	0,24	0,12	0,30	0,06
0,18	26,33					
0,30	25,98					
0,24	25,86	3.34	3.34			
0,12	25,11	4.97*	3.34			
0,06	22,85	6.67*	6.67*	6.67*	3.33	
0,00	20,44	13.34*	13.34*	10.00*	10.00*	6.67*

*   =   significantly different (P<0,05)

Density of *Gracilaria* sp. 0.18 gram/m2 gives the best contribution to the growth of individual weights of tiger shrimp.

3. Survival of Tiger Shrimp (*P. monodon* Fab.)

The data of tiger shrimp survival were normal, homogeneous, additive and significantly different between treatments. BNT test results on the survival rate of tiger shrimp presented in Table 5.

Table 5. BNT Test Result on Tiger Shrimp Survival Rate

Density of *Gracilaria* sp. (gram/m^2)	Average (%)	Difference with density... (gram/m^2)				
		0,18	0,24	0,12	0,30	0,06
0,18	76.67					
0,24	76.67					
0,12	73.33	3.34	3.34			
0,30	73.33	3.34	3.34			
0,06	70.00	6.67	6.67	6.67	3.33	
0,00	63.33	13.34*	13.34*	10.00	10.00	6.67

*   =   significantly different (P<0,05)

The survival rate of shrimp on density *Gracilaria* sp. 0.18 gram / m2 is relatively the same as 0.24 gram / m2 density and better than other treatments.

4. Feed Convertion Ratio (FCR)

The data of feed conversion ratio of shrimp is normal, homogeneous, but not additive and not significantly different between the spreading density treatment of *Gracilaria* sp.

5. Changes of Physical-Chemical Water Parameter, *Gracilaria* sp. weight increasing and Tiger Shrimp

Changes of physical-chemical water parameter in culture medium,*Gracilaria* sp. weight increasing and Tiger Shrimp and their survival are presented in Table 6.

Table 6. Changes in physical-chemical water parameters, weight gain *Gracilaria* sp. and tiger shrimp and its survival in various density of *Gracilaria* sp.

No	Aspect	Parameters	Density of *Gracilaria* sp. (gram/m^2)					
			0,00	0,06	0,12	0,18	0,24	0,30
1	Water quality that be limiting factors	pH (average)	7,52	7,65	7,69	7,70	7,73	7,73
		DO (ppm)	+0,16	+0,37	+0,37	+0,74	+0,74	+0,74
		Ammonia (ppm)	-0,06	-0,09	-0,08	-0,15	-0,16	-0,17
		Phosphate (ppm)	-0,01	-0,03	-0,02	-0,04	-0,03	-0,03
		Nitrite (ppm)	-0,28	-0,27	-0,27	-0,28	-0,28	-0,29
		Nitrate (ppm)	-0,28	-0,30	-0,31	-0,31	-0,31	-0,31
2	Growth of *Gracilaria* sp	Increase in biomass (gram)	--	+83,01	+78,91	+117,22	+72,82	+72,82
3	Growth of the Tiger Shrimp	Increase in biomass (gram)	+20,44	+22,85	+25,11	+26,33	+25,86	+25,98
4	Survival of the Tiger Shrimp	% of Average	63,33	70,00	73,33	76,67	76,67	73,33

6. Content of organic N, P, C on Seaweed (*Gracilaria verrucosa*)
At the start of the study, the nitrogen (N) content of 1.90% was absorbed in seaweed at the base and 1.72% were already absorbed in seaweed at the tip before the study. At the end of the study, the detected nitrogen (N) content of 2.41% was absorbed in seaweed at the base and by 2.25% absorbed at the end of the seaweed. The illustration is presented in Figure 1.
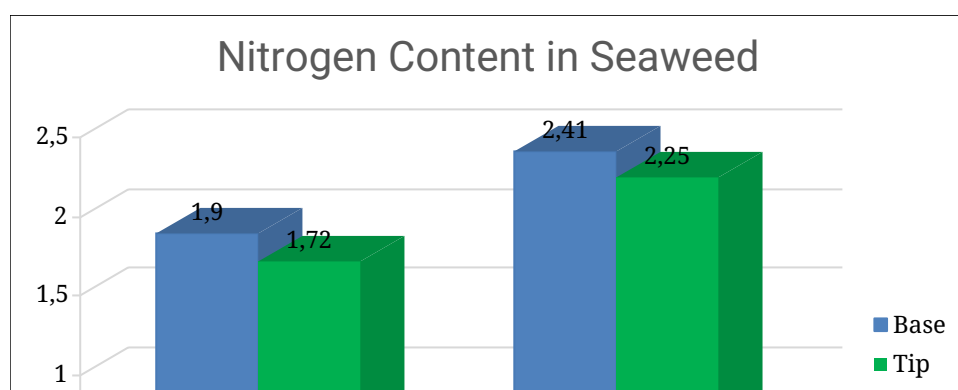
Figure 1. Content of nitrogen elements absorbed in seaweed.

Phosphorus (P) content that has been absorbed in seaweed the base of 0.15% and at the tip 0.10% at the beginning of the study. After the study of phosphorus (P) content was detected 0.13% absorbed in seaweed at the base and 0.14% at the tip as illustrated in Figure 2.
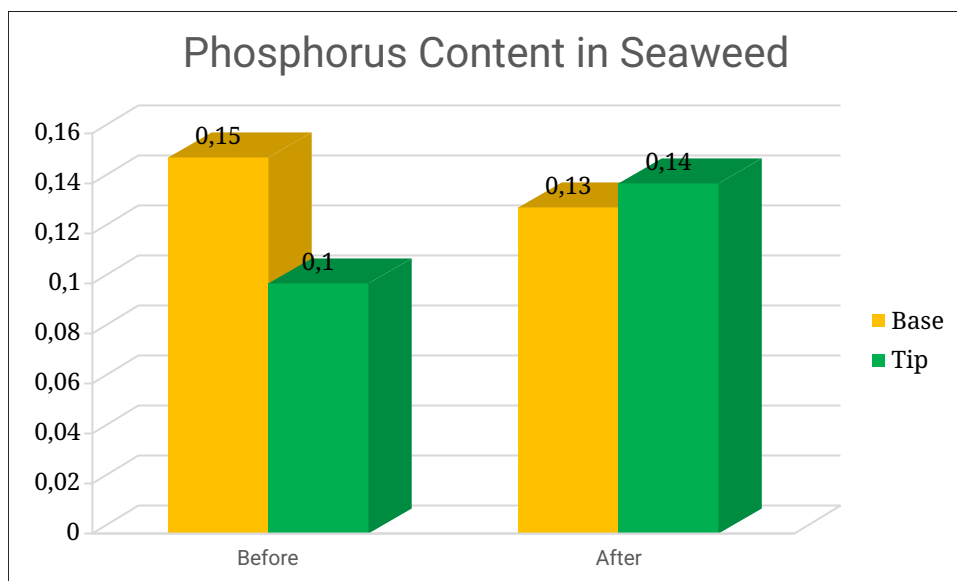

Figure 10. Content of phosphorus elements absorbed in seaweed.

The organic C content absorbed in seaweed at the base of 30.50% and at the end of 30.32% before the study. After research of organic content of C was detected 30,71% absorbed at base of seaweed and 29,93% absorbed at the tip as shown in Figure 3.
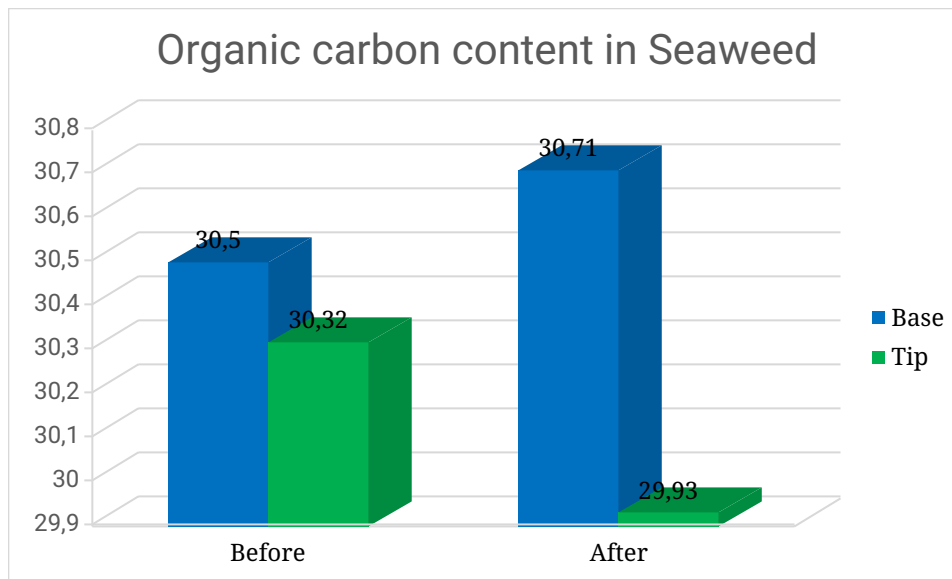
Figure 11. Content of Organic carbon elements absorbed in seaweed.

The organic C content absorbed in seaweed at the base of 30.50% and at the end of 30.32% before the study. After research of organic content of C was detected 30,71% absorbed at base of seaweed and 29,93% absorbed at the tip as shown in Figure 3.

7. Model The Role of Seaweed *Gracilaria* sp. as biofilter agent on the cultivation of Tiger Shrimp

The causal loop diagram and the dynamic model of shrimp polyculture cultivation with the Gracylaria sp biofilter are presented in Figures 4 and 5.
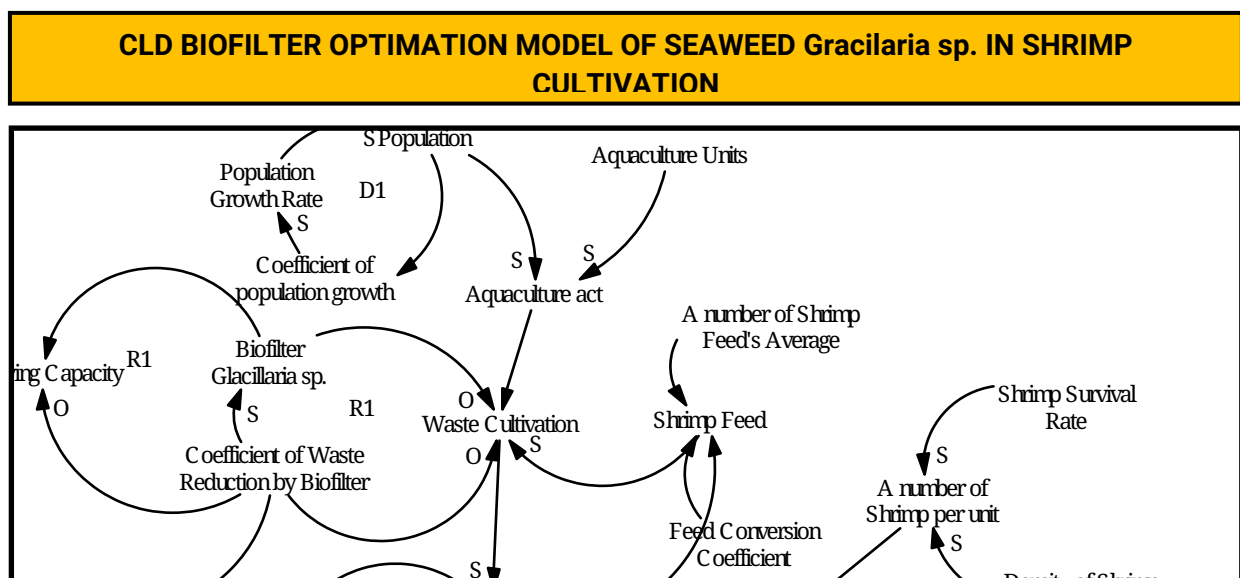
Figure 4. The causal loop effect of seaweed biofilter to improve water quality of culture media.

The validity of the aquaculture model with the biofilter system is done by comparing factual data of the cultivation unit at the study site compared with the simulated model obtained. Database used in 2010. Validated data based on 2010 to 2015. The data validation of aquaculture culture model as follows:

Years	(St)	(At)	MAPE
	Simulation	Actual	
2010	20	20	0
2011	22	21	4,76
2012	22	21	4,76
2013	24	22	9,1
2014	25	20	25
2015	32	30	6,66
			8,38

The result of model validity test obtained MAPE value of 8.38%, the value is still relatively high that is more than 5%, but still below 10%. Morecroft (2007) states that the MAPE value of 5-10% is still categorized as appropriate to describe the real condition.
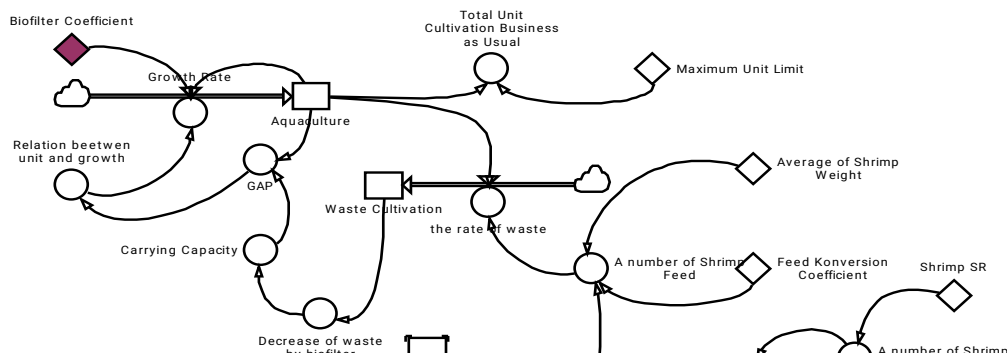
Figure 5. Dynamic model of shrimp polyculture cultivation with biofilter
Gracilaria sp.
Model simulations are performed within 2015-2045. The simulations include

cultivation waste prior to being given the role of biofilter, the role of biofilter in reducing biofilter waste, environmental carrying capacity and community income with the role of seaweed biofilter. The existence of a model simulation is intended to provide a temporal picture with the addition and subtraction of the model. The dynamic model results of biofilter role in sustainable brackish water development are simulated as follows:
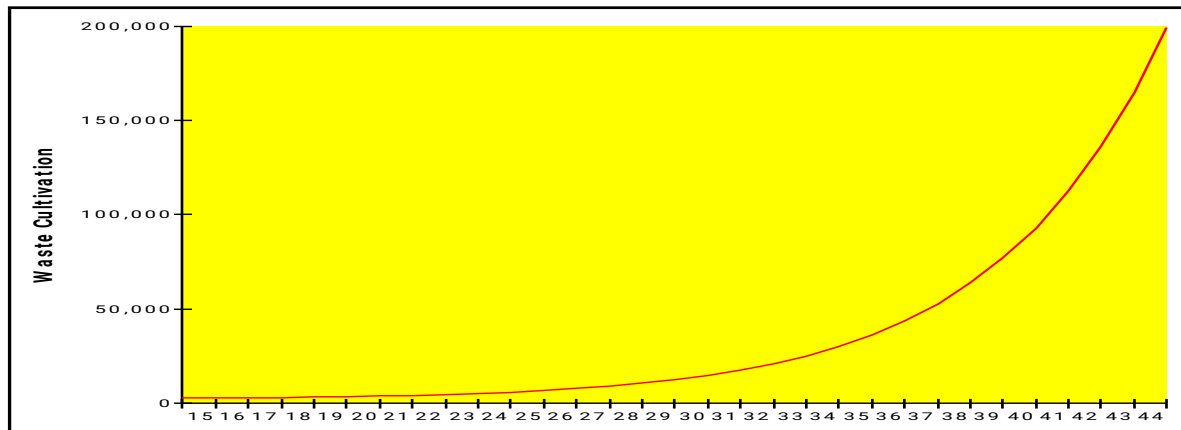
Figure 6. Graph of cultivation waste simulation (kg / year)

The result of simulation of sub model of cultivation waste before existence of biofilter role shows growth pattern of exponential growth, or experiencing increase of load with time. Increase in waste based on simulation results in 2026 increased 0.78% per year, the number continues to increase with the year.
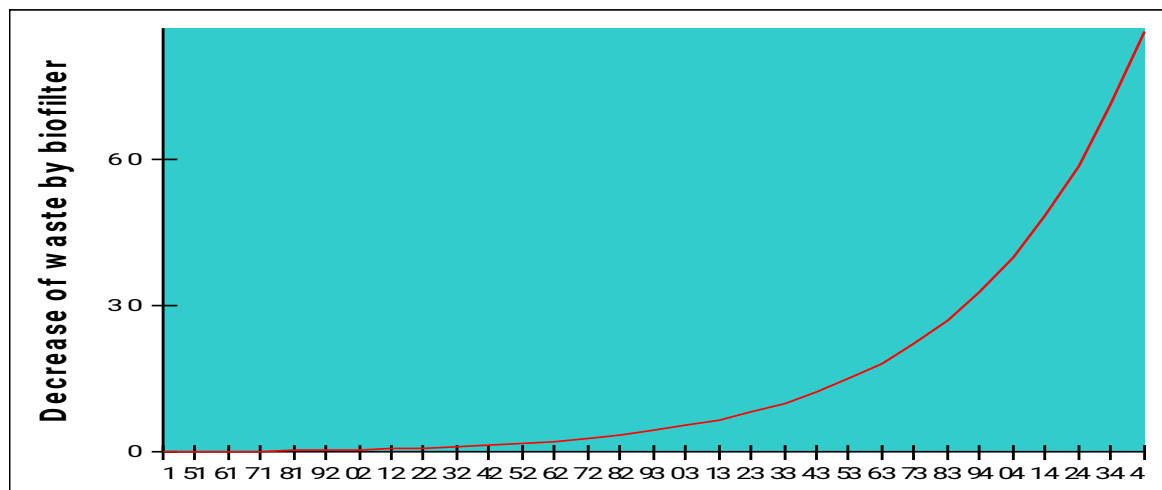

Figure 7. Simulation graph of waste reduction by Biofilter (Kg/Year)

Simulation of the role of biofilter in reducing waste shows that in year 2024 seaweed type *Gracilaria* sp. exponentially decreasing waste. The rate of waste reduction by seaweed in the year amounted to 1.07 tons per year. Based on the simulation, in 2045 the waste reduction reached 86.17 tons. The decrease of cultivation waste in the presence of seaweed biofilter is correlated with increasing seaweed biomass as time increases.
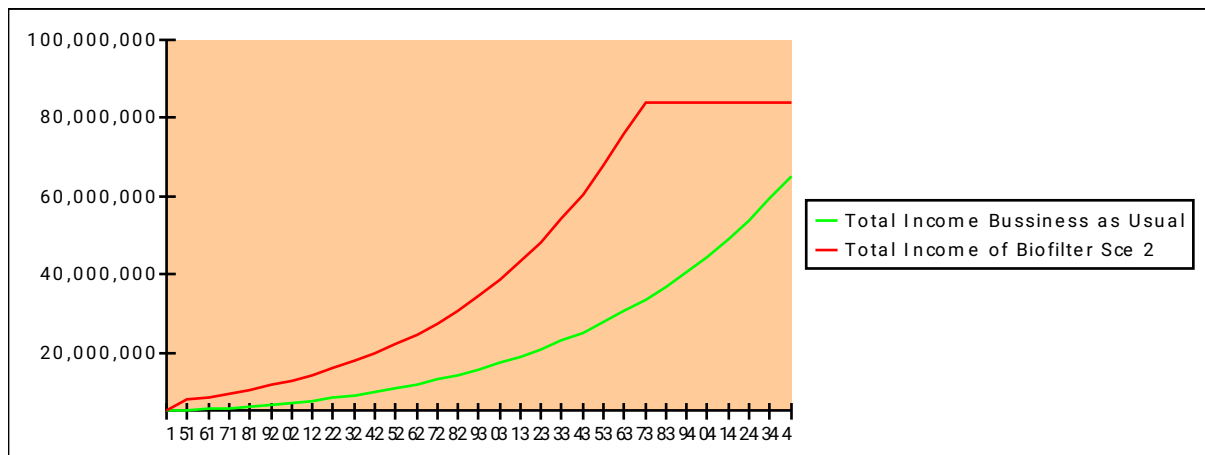

Figure 8. Graph of simulated total income of cultivation

The results of business as usual income simulation in the first year amounted to Rp 50.000.000, -. The income of the community in the first year with the scenario of increasing the biofilter coefficient from 1 to 1.2 has increased the income to Rp 70,925,190. The income level of the cultivators using biofilter reaches its peak in 2038 with income reaching Rp 830,697,159.- After 2038 the amount of income tends to remain, as the saturation level of seaweed filters the cultivation waste.

DISCUSSION

In most open shrimp cultivation systems 90% of N and P inputs are in the form of feed, and most of them are lost into the system and less than one-sixth are assimilated in shrimp biomass. Shrimp can only assimilate about 23-31% N and 10-13% P at total input. The main source of nutrient input for shrimp is feed, which contains about 76-92% N and 70-91% P of total input. The main nutrients are submerged in the sediments of 14-53% N and 39-67% P of total inputs. The water that flows at harvest contains 14-28% N and 12-29% P of the total input. Nitrogen content is a limiting factor for seaweed cultivation because it plays a role in regulating growth also in the regulation of metabolism and reproduction. Assimilation N requires an inorganic form of N in the seawater environment to become an organic form, such as amino acids

and other components. This is because N is indispensable for the biosynthesis of amino acids and proteins. The nitrogen content may vary or not on the Eucheuma thallus. while NH4 + in aquaculture medium is known to decrease during the study. In principle, changes in the water column have been utilized by seaweed, and most of the N-ammonia present in the pond has been used to a low level <10 µM. In addition, seaweed can also significantly alter the amount of phosphate present in the water. Seaweed can utilize nitrite and nitrate when N-ammonia is below 1 to 2 mg / l (Risjani, 2000).

Orthophosphate (PO4) is a phosphate fraction that can be directly absorbed by phytoplankton in photosynthesis. In general, phosphate is found in natural waters in small concentrations. Phosphate concentration of 1 mg / l is optimal enough for the growth of phytoplankton. Boyd (1988), states that the presence of phosphorus in natural waters is usually relatively small, levels less than nitrogen, because fewer sources of phosphorus than nitrogen sources in the waters. Phosphate is one of the macro nutrient for algae in the waters. In aquatic ecosystems phosphorous shaped into organic and inorganic compound. Phosphorus in inorganic compounds is orthophosphate (PO4), metaphosphate and polyphosphate, whereas organic phosphate is present in the body of an organism or organic compound. Phosphate compounds have break-off cycles due to their reactive nature that is easily bound by sediment but is difficult to dissolve back into the water. The accuracy of the concentration of orthophosphate in water will stabilize the growth of phytoplankton.

Seaweed or algae as other chlorophyll plants require nutrients as raw materials for the process of photosynthesis. To support the growth required the availability of nutrients in the water. Entry of materials or nutrients into the body tissue of seaweed is by the process of diffusion that occurs on all parts of the surface of the body of seaweed. When more diffusion, will accelerate the metabolism process that will increase the rate of growth. The diffusion process is influenced by environmental factors primarily by the presence of water movement (Boyd, 1988).

Model simulation results show the level of seaweed's ability to absorb cultivation waste. Over the years, cultivation wastes will be absorbed larger by the behavior of the exponential growth model. Absorption rate of waste by seaweed *Gracilaria* sp. based on the simulation will decrease the ability as time increases. *Gracilaria* sp. Seaweed capability in improving water quality, based on model will increase cultivation productivity and farmer's income. Mulatsih and Nurjanah (2015) stated that the existence of seaweed cultivation in brackish water can improve the quality of brackish environment, especially the organic matter of nitrate and phosphate.

CONCLUSIONS AND SUGGESTIONS

The conclusions obtained from the results of this study are as follows: The existence of seaweed with density 18 gram / m^2 give a significant influence to the reduction of Nitrogen and Phospor level as nutrient elements in aquaculture media so that affect the increasing productivity of shrimp farming and increase the income of farmer community.

SUGGESTION

Further study needs to be done related to the role of seaweed *Gracillaria* sp in absorbing metal elements that affect the productivity of tiger shrimp in the cultivation of polyculture.

ACKNOWLEDGMENTS

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