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Analysis of Seawater Quality on the Sustainability of Seaweed Cultivation on the Coast of Nusa Penida, Bali

Nyoman Sudipa

Regional and Rural Planning Study Program, Postgraduate, Mahasaraswati University
Jalan Soka No. 47 Denpasar, Bali, Indonesia
Corresponding author: nyoman_sudipa@unmas.ac.id

Abstract. Seaweed is an economic resource for the coastal communities of Nusa Penida which can improve people's lives. Seaweed is existence depends on the quality of the coastal waters of Nusa Penida. This study aims to determine the quality of the Nusa Penida coast to support the sustainability of seaweed cultivation. This research uses a quantitative approach to analyze seawater quality. The results of the calculation of the pollution index show that the seawater quality on the coast of Nusa Penida is in good condition, meeting water quality standards based on water quality standards for marine biota by the Regulation of the Governor of Bali No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage, which means that it is very feasible for seaweed culture. The parameters that affect the marine water pollution index are TDS, ammonia, and nitrite parameters in Jungutbatu seawater, Nitrite in Toyapakeh seawater, TDS, Ammonia and nitrite in Penida seawater, Nitrite in Buyuk Kutampi sea water, Ammonia and Nitrite in Sampalan seawater, and Nitrite in Suana seawater.

***Keywords*:** quality; water; seaweed; quality standards

I. INTRODUCTION

Nusa Penida Island consists of three island clusters: Nusa Penida Island, Nusa Lembongan, and Nusa Ceningan. Nusa Penida Island is an atoll island with karst rocks all over the island. The island of Nusa Penida has superior commodities, namely *Eucheuma spinosum* and *Eucheuma spinosum cottoni*. Long before tourism developed in Nusa Penida, seaweed was a mainstay commodity for the coastal communities of Nusa Penida and had great hopes for improving the community's economy [1]. After tourism developed, slowly seaweed cultivation began to be abandoned with the excuse that tourism made money faster. After the COVID-19 pandemic, the coastal communities of Nusa Penida realized that tourism was very vulnerable to disease and security issues and could not be the sole economic foundation. The coastal communities of Nusa Penida are turning seaweed into a new economic source, even though there are reasons that the quality of seawater has been polluted. The quality of seawater has an important role in the survival of marine life and for the benefit of cultivation [2]. The seaweed cultivation process is in demand by the coastal communities of Nusa Penida because it is easy to maintain, the harvest process is quite short and the price is stable [3].

Efforts to utilize the Nusa Penida coast for seaweed cultivation must consider aspects of the aquatic environment. The quality of seawater plays an important role in the growth of seaweed. The success of seaweed cultivation is largely determined by the physical and chemical parameters of seawater [4]. The seawater quality sample assessment was carried out in the coastal area of Nusa Penida which has been used as a place for cultivating seaweed. Analysis of physical, chemical, and microbiology parameters using quality standards based on the Regulation of the Governor of Bali No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage [5]. The use of the coast as a place for cultivation in the past has increased community empowerment from a social, economic, and cultural perspective [6]. The social and economic side raised is the welfare condition of the coastal community from the economic growth caused by the results of grass cultivation which has changed the face of Nusa Penida, which is poor, which can be lifted because of seaweed [7]. Cultural change lies in the way people think. which changed due to increasing interest in higher

education among the people of Nusa Penida due to an increase in the economy.

This study aims to analyze the quality of seawater on the coast of Nusa Penida, and whether it is by the sustainability of seaweed cultivation. This study uses a quantitative approach to analyze seawater quality.

II. RESEARCH METHODS

The materials needed to analyze the quality of seawater are sterile bottles and cold box Secchi disks, digital thermometers, refractometers, pH meters DO meters, and cool boxes. For the analysis of seawater quality using a standard quality approach based on the Regulation of the Governor of Bali No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage. Determination of pollution status is determined by using a pollution index as stated in the Decree of the State Minister for the Environment Number 51 of 2004 as follows:

$$PIj = \sqrt{\frac{(\frac{Ci}{Lij})_M^2 + (\frac{Ci}{Lij})_R^2}{2}}$$

Information:

Li is water quality parameters in water quality standards for water designation (j); Ci is concentration of water quality parameters from survey results; Pij is Pollution index for designation (j); (Ci / Lij) M is Maximum Ci / Lij Value; (Ci / Lij) R is Average Ci / Lij Value.

The relationship between the level of pollution and the status of water quality is as follows:

1. $0 \leq PIj \leq 1.0$ is Meet the quality standard (good condition)
2. $1.0 < PIj < 5.0$ is lightly polluted
3. $5.0 < PIj \leq 10$ is moderately polluted
4. $PIj > 10$ is heavily polluted

Samples were taken in the seaweed cultivation area on the north coast of Nusa Penida. There are 6 points of seawater samples taken, namely Jungutbatu seawater, Toyapakeh seawater, Penida seawater, Buyuk Kutampi seawater, Sampalan seawater, and Suana seawater. The water samples were analyzed based on physical, chemical, and microbiological parameters as presented in Table 1. The quality standards used were water quality standards for marine biota following the Regulation of the Governor of Bali No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage.

TABLE I
WATER SEA QUALITY PARAMETERS ANALYSIS

No	Parameters	Unit		Gub Regulation No. 16 of 2016 Marine Biota
A.	PHYSICS			
	1. Temperature	^0C		26-30
	2. Smell			Alami
	3. Turbidity	ppm SiO2	< 10	
	4. TDS	ppm	≤ 20	
B.	CHEMISTRY			
	1. pH			6,5-8,5
	2. Cu	ppm		0,008
	3. Zn	ppm		0,05
	4. Cr	ppm		0,005
	5. Cd	ppm		0,001
	6. Hg	ppm		0,001
	7. Pb	ppm		0,008
	8. As	ppm		0,012
	9. Se	ppm		-
	10. Amonia bebas (NH_3-N)	ppm		0,3
	11. Nitrit (NO_2-N)	ppm		-
	12. Deterjen	ppm		1
C.	MICROBIOLOGY			
	1. Total coliform	MPN/100ml		1000
	2. Faecal coliform	MPN/100ml		0

Source: Bali Governor Regulation no. 16 of 2016

III. RESULT AND DISCUSSION

The results of the analysis of seawater samples show that in general, based on the pollution index, the quality of seawater on the coast of Nusa Penida is in good condition and meets water quality standards to support the sustainability of seaweed cultivation. Based on the results of the analysis of physical, chemical, and microbiological parameters shown in Table 2, it shows that several parameters are above the quality standards, namely TDS, ammonia and nitrite in Jungutbatu seawater, nitrite in Toyapakeh seawater, TDS, ammonia and nitrite in Penida seawater, Nitrite in Buyuk Kutampi sea water, Ammonia and Nitrite in Sampalan. seawater, and Nitrites in Suana seawater. The parameters of TDS, ammonia, and nitrite in Nusa Penida waters will interfere with the growth of seaweed, such as high TDS will interfere with the intake of sunlight entering the waters, high ammonia will cause the accumulation of dissolved organic matter and affect the rate of decomposition of organic material which can disrupt the growth of seaweed [8]. Uncontrolled ammonia concentrations can cause major problems in the aquatic environment because ammonia toxicity can suddenly increase following changes in water quality factors, such as pH, temperature, ion charge, salinity, and dissolved oxygen (DO) [9]. If it exceeds the tolerance threshold, the toxic form of ammonia (NH3) can inhibit seaweed growth and even result in death. High nitrite will cause waters to become fertile and increase the growth of algae which will threaten the sustainable life of seaweed because algae attached to seaweed will disrupt the photosynthesis process [10].

TABLE II

RESULTS OF ANALYSIS OF SEAWATER QUALITY ON THE COAST OF NUSA PENIDA

No	Parameters	Unit	Sampling Location					
			LJ	LTP	LP	LBK	LS	LSN
A.	PHYSICS							
1	Temperature	^{0}C	27	27,5	27	27	27	27
2	Smell		odorless	odorless	odorless	odorless	odorless	odorless
3	Turbidity	ppm	8,92	2,8	6,68	3.2	1,06	3.2
4	TDS	ppm	32,8	12	22,92	14,4	8	9.2
B.	CHEMESTRY							
1	pH		8,1	8,2	8,23	8	8,02	8,2
2	Cu	ppm	nd	nd	nd	nd	nd	nd
3	Zn	ppm	nd	nd	nd	nd	nd	nd
4	Cr	ppm	nd	nd	nd	nd	nd	nd
5	Cd	ppm	nd	nd	nd	nd	nd	nd
6	Hg	ppm	nd	nd	nd	nd	nd	nd
7	Pb	ppm	nd	nd	nd	nd	nd	nd
8	As	ppm	nd	nd	nd	nd	nd	nd
9	Se	ppm	nd	nd	nd	nd	nd	nd
10	Amonia (NH_3-N)	ppm	0,582	0,224	0,466	0,213	0,488	0,182
11	Nitrit (NO_2-N)	ppm	0,022	0,026	0,014	0,032	0,008	0,01
12	Deterjent	ppm	0,032	0,023	0,0353	0,0422	<0,05	0,004
C.	MICROBIOLOGY							
1	Total coliform	MPN/100ml	20	40	10	25	10	10
2	Faecal coliform	MPN/100ml	0	0	0	0	0	0

Information: nd is no detected; LJ is Jungutbatu seawater; LTP is Toyapakeh seawater; LP is Penida seawater, LBK is Buyuk Kutampi seawater, LS is sampalan seawater, and LSN is Suana seawater. The results of the analysis of the seawater pollution index for each seawater sampling are as follows: (1) The index of water pollution for marine biota is 0.06, where the water is in good condition and meets the requirements as a place for marine biota to live; (2) The index of water pollution for marine biota is 0.07, where the water is in good condition and meets the requirements as a place for marine biota to live; (3) The index of water pollution for marine biota is 0.05, where the water is in good condition and fulfills the requirements for a place to live for marine biota; (4) The index of water pollution for marine biota is 0.04, where the water is in good condition and meets the requirements as a place for marine biota to live; and (5) The index of water pollution for marine biota is 0.07, where the water is in good condition and meets the requirements as a place to live for marine life.

Total Dissolved Solid (TDS) (exceeding the seawater quality standard threshold can be seen in the test results of Jungutbatu seawater samples and Penida seawater samples. The TDS is quite high in the test results of Jungutbatu seawater samples due to the presence of organic and inorganic compounds entering the water [11]. The condition of Jungutbatu waters which are close to mangrove forests causes many organic compounds to enter in the form of mud and mangrove leaf litter which enter the waters and it is found that there is soil dredging activity for the construction of tourism accommodations near Jungutbatu waters. which causes organic and inorganic particles to run off into the waters [12]. The conditions are almost the same in Penida seawater which is caused by the estuary that enters the Penida beach and the presence of project activities around the Penida coast which results in Organic compounds entering the waters The results of the TDS parameter analysis are presented in Figure 1.

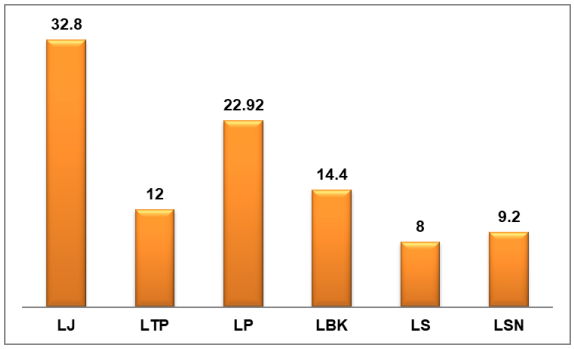

Figure 1. Total Dissolved Solid Parameters Analysis

The ammonia parameter exceeds the quality standard threshold according to the water quality standard for marine biota following the Regulation of the Governor of Bali No. 16 of 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage, namely a maximum of 0.3 ppm, namely in Jungutbatu Sea, Penida Sea, and Sampalan Sea Waters. Quite high levels of ammonia in Jungubatu Sea Waters are caused by the waste of human and animal urine entering the waters. The Jungutbatu area is densely populated with tourism activities which of course cause waste material in the form of urine which eventually enters the waters. Ammonia is one of the toxic pollutants in marine waters if the concentration is above the quality standard threshold [13]. Ammonia is also caused by the metabolism of aquatic organisms and the process of decomposing organic matter or organic waste such as household waste and others by bacteria that are carried away by the current [14]

The high concentration of ammonia in Penida's sea waters is due to the presence of residual organic matter, the results of decomposition of waste and urine originating from the upper reaches of the Penida river and organic waste originating from the activities of residents around Penida's sea waters which run off during the rainy season. the source of ammonia in the waters is also the result of the breakdown of organic nitrogen (protein and urea) and inorganic nitrogen found in water. The increase in ammonia levels in the sea is closely related to the entry of organic matter that is easily decomposed [15]. The waters of the Sampalan Sea have ammonia parameters above the quality standard threshold because the Sampalan area is dense with settlements on the coast which causes organic waste and garbage to enter the waters which causes an increase in ammonia levels in coastal waters. Ammonia levels that are at the threshold of quality standards will poison all organisms in the waters [16]. Population growth in an area creates pressure on the aquatic environment and has the potential to produce waste such as ammonia [17]. The results of the analysis of ammonia parameters can be seen in Figure 2.

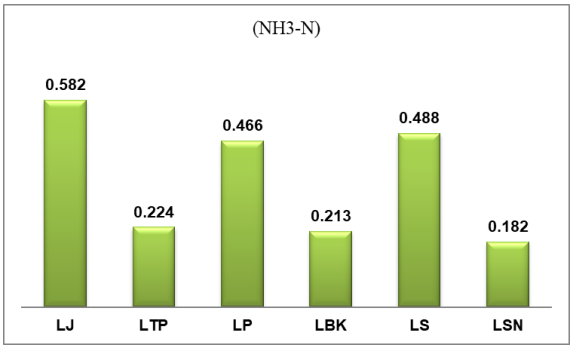

Figure 2. The Ammonia Parameters Analysis

Nitrite levels in marine waters on the north coast of Nusa Penida are caused by activities in the upstream areas such as agriculture, industry, and settlements which continuously enter the waters, accumulate, and can become pollutants that interfere with the life of microorganisms in coastal waters [18]. The highest nitrite concentrations are found in the Buyuk Kutampi Sea and the Toyapakeh Sea. This is because this area is densely populated with tourism, port, and trade activities which are very close to the coast which causes the waste of organic matter, garbage, and human and animal waste to enter the waters more easily [19]. This condition will increase the pressure on the coastal environment. Nitrite is generally a transitional form between ammonia and nitrate and immediately changes to a more stable form, namely nitrate and nitrite are key parameters in determining water quality because they are toxic. Nitrite in water can come from the ammonia oxidation reaction by Nitrosomonas bacteria [20]. The results of the analysis of nitrite parameters can be seen in Figure 3.

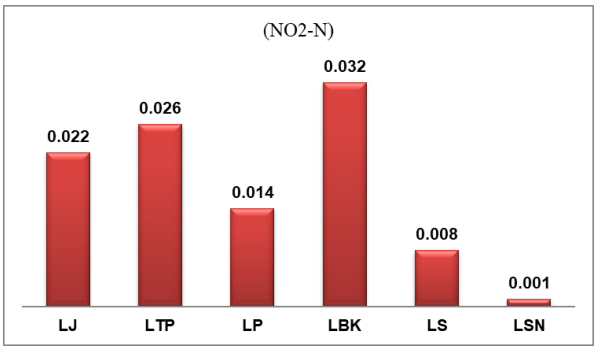

Figure 3. The Nitric Parameters Analysis

IV. CONCLUSION

The results of analysis of the quality of Jungutbatu seawater, Toyapakeh seawater, Penida seawater, Buyuk Kutampi seawater, Sampalan seawater, and Suana seawater using pollution index calculations show that it still meets seawater quality standards for marine biota by Bali Governor Regulation No.16 2016 concerning Environmental Quality Standards and Quality Standard Criteria for Environmental Damage shows that it is still feasible to continue seaweed cultivation. Several parameters that influence the seawater pollution index are TDS parameters (32.8 ppm), ammonia (0.528 ppm) and nitrite (0.022 ppm) in Jungutbatu sea water, Nitrite (0.026 ppm) in Toyapakeh sea water, TDS (22.92 ppm), Ammonia (0.446 ppm) and nitrite (0.014 ppm) in Penida sea water, Nitrite (0.032 ppm) in Buyuk Kutampi sea water, Ammonia (0.488 ppm) and Nitrite (0.008 ppm) in Sampalan sea water, and Nitrite (0, 01 ppm) in Suana seawater which is still above the quality standard threshold. The high concentration of TDS, ammonia, and nitrite in these waters will inhibit the growth of seaweed, and can even cause the death of seaweed. Waste management needs to be carried out in land areas to reduce the concentration of dangerous organic compounds entering Nusa Penida waters.

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