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Kepada: I Ketut Sumantra <ketut.sumantra@unmas.ac.id>, Made Gede Soken <imadegedesoken@gmail.com>, I Wayan Gde Wiryawan <gdewiryawan@unmas.ac.id>, I Made Wahyu Wijaya <wijaya@unmas.ac.id>

Dear I Ketut Sumantra, Made Gede Soken, I Wayan Gde Wiryawan, I Made Wahyu Wijaya,

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RESEARCH ARTICLES

Marine Water Pollution Index in Intensive Shrimp Cultivation System in Jembrana

Go ahead Sumantra [a,*] , Made Gede Soken [a] , Wayan Gede Wiryawan [b] , I Made Wahyu Wijaya [a]

[a] Master's Program in Regional Development Planning and Management Environment, Postgraduate Mahasaraswati University Denpasar, 80231 Denpasar, Bali, Indonesia; [b] Master of Law Study Program, Faculty of Law, Mahasaraswati University Denpasar 80231 Denpasar, Bali Indonesia

Abstract Intensive shrimp cultivation with a high level of shrimp biomass and feeding will also result in high waste disposal. This condition can cause pollution in the surrounding waters and reduce the quality of the environment, which will threaten the sustainability of the environment and the sustainability of shrimp cultivation on the shrimp farm. The problem is the pollution load of shrimp farm wastes in the intensive cultivation system and the pollution status of coastal waters. This study aims to analyse the pollution load of shrimp farm wastes and the pollution status of coastal waters. This research was carried out in the coastal area of Jembrana District for four months, from March to June 2022. It was conducted by collecting data directly in the field. Samples were taken by purposive sampling method, namely at the inlet and outlet of the reservoir, the outlet of the shrimp farm, the outlet of the WWTP, coastal waters and marine waters. The pollution load level of shrimp farm waste at each station refers to the Minister of Environment Decree No. 54 of 2004, and the marine water pollution index refers to the Minister of Environment Decree No. 115 of 2003. The pollution load of shrimp farm waste based on the parameter concentration value has passed the thresholds for the quality standards of source water and maintenance water, which are: 1). Free ammonia (NH3-N) at ST 1, ST 2, ST 3, and ST 4; 2). Nitrate (NO3-N) at ST 1, ST 2, ST 3, and ST 4. A load of waste generated from shrimp rearing farms was free ammonia at 3.3 tons/ha/year and nitrate at 555.96 kg/ha/year. In contrast, the pollution load of waste discharged into coastal waters from shrimp farm wastewater treatment plants was free ammonia at 2.06 tons/ha/year and nitrate at 475.96 kg/ha/year. The pollution index of coastal waters in the shrimp farm cultivation area in Jembrana District was classified as moderately polluted with a Pij of 7.67 and heavily polluted (Pij = 11.09) according to 80 days of observation and 110 days of shrimp rearing. Meanwhile, in marine waters, the level of pollution was in the moderate category during the 80-day and 110-day observation periods. Maintaining the preservation of the marine environment requires an analysis of the capacity of the organic waste of shrimp farms on the carrying capacity of the aquatic environment. Therefore, it can be used as a reference in formulating policies for the development of Vannamei shrimp cultivation areas in Jembrana District, Jembrana Regency.

Keywords: Waters, Marine, Farm, Pollution, Shrimp, Cultivation.

Introduction

The Vannamei shrimp cultivation business has high economic value and potential in both local and international markets. This promising opportunity causes shrimp farmers to further increase their production due to the consideration of large profits. The farmers try their best to produce maximum business productivity, and one of the ways is by managing the farm business intensively with maximum stocking density and optimal feeding. In commercial aquaculture, as much as 30% of the total feed is not consumed by fish, and about 25%-30% of the consumed feed will be excreted [1]. The amount of nitrogen (N) and phosphorus (P) in the feed will be retained in the fish meat between 25%-30%, and the rest is wasted into the marine environment [2]. An intensive shrimp cultivation system will cause input load in the form of shrimp feed into the cultivation media. It will lead to waste disposal of organic matter, toxic nitrogen nutrients and dissolved faeces into the waters. The impact that arises is water pollution and will reduce the quality of the environment. Water pollution affects the sustainability of shrimp cultivation in farms. Sources of water pollution can be derived from solids and dissolved forms. Solid forms include feed residues, fish faeces, and bacterial colonies, while dissolved forms include ammonia, urea, carbon dioxide, phosphorus, and hydrogen sulphide [3]. Such waste will increase with low feed conversion. The N and P retention of Vannamei shrimp feed in the rearing phase were 22.27% N and 9.79% P, respectively, so the nutrients wasted in the farm waters reached 77.73% N and 90.21% P, respectively [4]. Intensive exploitation of farms for shrimp cultivation not only harms coastal areas but also results in an unsustainable aquaculture industry [5]; [6]. Waste generally contains high Total Suspended Solid (TSS), phytoplankton and nutrients. The main nutrients found in shrimp farm cultivation waste are high levels of nitrogen and phosphorus [7], and the pH of the water is alkaline, pH 7-9 [8]. The amount of waste wasted in the form of N and P is largely determined by the farm's production capacity. The higher the farm production per unit area, the greater the N and P waste that is wasted into the waters [9]. This condition causes high concentrations of TSS, COD, BOD, total nitrate, and phosphate in coastal waters. The magnitude of the load of each of these parameters discharged into the waters from sequential aquaculture locations is: 3,533.3 kg/ha (TSS); 7,824.4 kg/ha (COD); 735.6 kg/ha (BOD); 167.8 kg/ha (total nitrate); and 3.0 kg/ha (total phosphate) [10]. The results of the Vannamei shrimp disease surveillance in 2021 carried out by BKIPM Denpasar showed that in the shrimp farm area in Jembrana Regency, there had been an EHP (Enterocytozoon hepatorenal) disease attack with a spread rate of up to 100%. The disease attack occurs as an effect of waste disposal from shrimp farms. Therefore, shrimp farm wastewater to be discharged into the nearest water body must meet the applicable quality standards so as not to pollute local waters. The problem is how the pollution load of shrimp farm waste and the pollution status of coastal waters is due to the waste of the shrimp cultivation system dumped on the coast. Therefore, the research objectives are 1) to analyse the pollution load of shrimp farm waste; 2) to determine the pollution status of coastal waters due to intensive shrimp cultivation waste disposal.

Commented [U1]: The author should explain more about the description of waste water flow conditions in the coastal area

Materials and Methods

Sampling wastewater quality from shrimp farms and coastal waters used the integrated sample method with purposive sampling, namely sampling in two shrimp farm units using intensive aquaculture technology. The sampling station locations were divided into six sampling stations. As for the location of the water sampling station, observations were made at two intensive shrimp farms and two coastal water locations as follows: 1). Unit 1 (ST.1A) and unit 2 (ST.1B) shrimp farm reservoir inlets, 2). Shrimp farm tank outlets unit 1 (ST.2A) and unit 2 (ST.2B), 3). Outlets of shrimp rearing farm unit 1 (ST.3A) and unit 2 (ST.3B), 4). Shrimp farm WWTP outlets unit 1 (ST.4A) and unit 2 (ST.4B), 5). Coastal Waters location 1 (ST.5A), location 2 (ST.5B), and 6). The marine water is 600 meters from the shoreline of location 1 (ST.6A) and location 2 (ST.6B) (Figure 1).

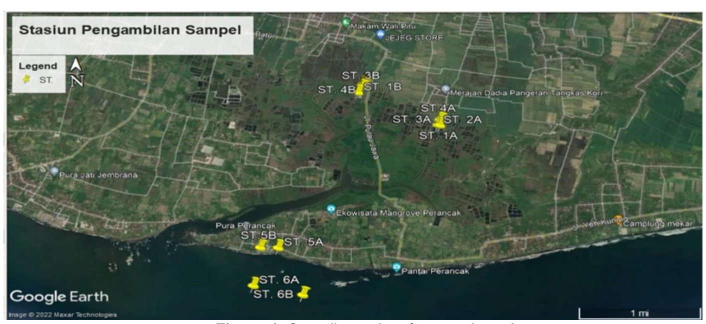

Figure 1. Sampling points from each station

The samples that had been obtained were then analysed in the field and at the Health Laboratory of the Bali Provincial Health Office. The field and laboratory analysis results were used as guidelines for determining the pollution level from each research location. Water quality samples were observed in two stages: the first stage on 80-day-old shrimp and the second on 110-day-old shrimp.
Water quality data were analysed descriptively and compared with the quality standards of source water and maintenance water based on Ministerial Decree No. 75 of 2016 and marine water quality standards for marine biota according to Minister of Environment Decree No: 51 of 2004.
Table 1. Parameters and methods of water quality analysis

No	Parameter	Analysis Method	Measurement Place
a.	Physical Parameter		
	Temperature	Mercury thermometer	In situ
	TSS	Gravimetry	Laboratory
	Brightness	Secchi disc	In situ
b.	Chemical Parameter		
	pH	pH meters	In situ
	Salinity	Refractometer	In situ
	Dissolved oxygen	DO meters	In situ
	BOD	Electrometry	Laboratory
	Ammonia	Nessler	Laboratory
	Nitrate	Brucin	Laboratory
	Nitrite	Brucin	Laboratory
	Phosphate	Amm-Molybdate	Laboratory
	Heavy Metal: CD, Pb, Hg	AAS AAS Mercury Analyzer	Laboratory Laboratory Laboratory
	H2S	Spectrophotometry	Laboratory
	Alkalinity	Telemetry	Laboratory

The analysis of the pollution status of coastal waters in this study used the Pollution Index (PI) method based on the values of several water quality parameters that have been previously determined, namely the parameters of Temperature, Salinity, pH, O2, Alkalinity, BOD, Ammonia, Nitrite, Nitrate, Phosphate, Brightness, TSS, Heavy Metal, and H2S. Determination of the water quality status of coastal waters used the Pollution Index (IP) method of Coastal Waters by determining the status of water quality according to the Decree of the State Minister of the Environment, 2003, with the following formula:

$$Pij = \sqrt{\frac{(Cij/Lij)^{2}\mathrm{M} \mathrm{Cij}/\mathrm{Lij})^{2} R}{2}}$$

Where:
Lij = Concentration of water quality parameters listed in the quality standard of water designation (J)
Ci= Concentration of water quality parameters in the field
Pij= Pollution index for designation (J)
(Ci/Lij)R = value, Ci/Lij average
(Ci/Lij)M = value, maximum Ci/Lij

Table 2. Pollution Criteria

	Pollution Index	Description
1.	0 < Pij < 1.0	Meets quality standards (good condition)
2	1.0 < Pij < 5.0	Light pollution
3.	5.0 < Pij < 10	Moderate pollution
4.	Pij > 10	Heavy pollution

Source: Minister of Environment Decree No: 115, 2003

Results and Discussion

Commented [U2]: In this section, there should be more in-depth discussion of the findings in this study with previous similar findings.

The shrimp cultivation system in Jembrana District is generally carried out using semi-intensive and intensive technology with a stocking density of 50-165 fish/m². The Vannamei shrimp cultivation system at the rearing stage starts from the preparation, maintenance and harvesting stages. At the preparation stage, several treatments are carried out, such as drying for two weeks, removing farm bottom mud, then liming the farm bottom at a dose of 1-2 tons/ha and in the maintenance process, a dose of 0.5 tons/ha. The next stage is filling the farm water to a height of 1.5 m to 1.7 m and leaving it for 15 days. Then the stocking of the fry is done in the morning or evening, which is first acclimatized for 15 minutes. The stocking density of fry in shrimp farms is 165 fish/m² with a size of PL 10. The feed given is in the form of artificial feed in the form of pellets with a nutritional composition of 38-40% protein, 12% water content, 6% fat and 3% fibre. The amount of feed given is based on the needs of the shrimp and is calculated based on the average weight gain with a frequency of feeding 2-5 times a day. Vannamei shrimp feeding based on age refers to SNI 01-7246 – 2006.

The management of shrimp farm water quality is carried out by collecting incoming water taken from the primary canal at high tide and then tamping it in a tendon plot for treatment and deposition after it is channelled to the enlargement farm plot. During the enlargement phase, water changes are carried out periodically every two days, as much as 10-15% starting from 15 days old shrimp and according to farm water conditions. Furthermore, the basic siphoning of the shrimp farms is carried out periodically to maintain water quality in order to be able to support the survival of the shrimp, which is carried out starting at the age of 15 days. After that, it is done gradually on day 5, day 3, and then every two days. Harvesting of Vannamei shrimp is done partially and totally. Partial harvesting is done to reduce the density so that shrimp growth is more optimal and avoids death due to disease. Partial harvesting is generally done on 60 days old shrimp and is situational. The total harvesting is done by harvesting the whole shrimp by draining the farm and storing it in a net at the disposal gate. It is done after the shrimp are 112 to 120 days old with a size of 35 (35 fish/kg). At the time of observation, the harvest was carried out in total when the shrimp reached 112 days of age with size 35 with an average individual weight of 29 grams/head. The survival rate is 90%, with an average yield of 25.6 tons per ha. The percentage of the amount of feed consumed by fish during the maintenance cycle to be converted into fish body weight with an average ratio of 1.3. Measurement of the quality of the source water in the shrimp farm reservoir was carried out at the inlet of the reservoir, designated as station 1 and the exit door of the shrimp farm (outlet), designated as station 2. The measurement results based on in situ measurements and laboratory analysis can be seen in Table 3.

Table 3. Water quality at the inlet and outlet of the reservoir at the age of 80 days and 110 days of shrimp

No	Parameter	**Unit**	St.1		St.2		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	30	30	30	30	**28 – 30**
2	Brightness	meters	0.5	0.5	0.5	0.5	-
3	TSS	mg/L	4	7	2	6	-
4	pH	-	8.54	7.83	8.56	8.5	**7.5-8.5**
5	Salinity	%	**24.36***	**20.11***	**22.44***	**25,13***	**26-32**
6	Dissolved Oxygen (DO)	mg/L	8.68	7.65	7.89	7.25	**> 4**

7	BOD	mg/L	1.97	0.4	0.39	2.01	**□ 90**
8	Free Ammonia (NH_3-N)	mg/L	**9,216***	**2,370**	**0.737***	0.047	**□ 0.1**
9	Nitrite (NO_2-N)	mg/L	0.008	0.004	0.002	0.009	**□ 1**
10	Nitrate (NO_3-N)	mg/L	0.293	**0.57***	**0.858***	**0.61***	**0.5**
11	Phosphate (PO_4-P)	mg/L	0.182	<0.01	0.219	<0.001	**0.1-5**
12	Sulphide (H_2S)	mg/L	<0.01	<0.01	<0.01	<0.01	**□ 0.01**
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	**0.002**
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**0.01**
15	Timbal	mg/L	<0.0036	<0.0036	<0.0036	<0.0036	**0.03**
16	Alkalinity	mg/L	123.6	140	123.6	92.7	**100-150**

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)
Description:
*) Has exceeded the water quality standard
**) Based on KP Regulation Number 75 of 2016
ST 1: Inlet reservoir station
ST 2: Outlet reservoir station

The measurement of water temperature parameters at the study site ranged from 29ºC to 32ºC. The temperature ranges at stations 1 and 2 at 80 days and 110 days were still within the required quality standards, while at stations 3 and 4 at 80 and 110 days, measurements had exceeded the quality standards ranging from 31 - 32ºC. Based on the quality standards of source and maintenance water, the required temperature ranges from 27ºC to 30ºC.
The brightness of marine water at the study site at stations 1 and 2 is not required, while at station 3 (maintenance plot outlets) at 80 days measurement was 0.35 m, and at 110 days was 0.38 m, which was still in accordance with water quality standards for shrimp cultivation. On the other hand, at station 4 (outlet of the sewage treatment plant), at 80- and 110-days measurements was 0.25 m, which was below the quality standard for brightness, namely 0.3 - 0.5 m in source water and maintenance water.
Water quality measurement for the maintenance of Vannamei shrimp was carried out at the effluent gate of the enlargement farm as station 3 and the sluice gate of the wastewater treatment plant as station 4.

Commented [U3]: Please explain how the WWTP system implementation at this location

Table 4. Water quality of enlargement farm outlets and WWTP outlets at the age of 80 and 110 days of shrimp

No	Parameter	**Unit**	St.3		St.4		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	31	31	32	32	**>27**
2	Brightness	meters	0.38	0.35	0.25	0.25	**0.30-0.50**
3	TSS	mg/L	16	19	22	40	**-**
4	pH	-	8.17	8.01	8.18	7.75	**7.5-8.5**
5	Salinity	%	**21.28***	**22.3***	**13.13***	**13.57***	**26-32**
6	Dissolved Oxygen (DO)	mg/L	7.1	5.64	5.92	4.43	**> 4**
7	BOD	mg/L	15.79	6.04	15.79	7.05	**□ 90**
8	Free Ammonia (NH_3-N)	mg/L	**14,098***	**7,754***	**8,642***	**5,472***	**□ 0.1**
9	Nitrite (NO_2-N)	mg/L	0.603	0.742	0.018	0.317	**□ 1**
10	Nitrate (NO_3-N)	mg/L	**2,183***	**2.49***	**1,951***	**1.61***	**0.5**
11	Phosphate (PO_4-P)	mg/L	1,886	1.355	3,434	2.018	**0.1-5**
12	Sulphide (H_2S)	mg/L	<0.01	<0.01	<0.001	<0.01	**< 0.01**
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	**0.002**
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**0.01**

15	Lead	mg/L	<0.0036	<0.0036	<0.0036	<0.0036	**0.03**
16	Alkalinity	mg/L	**164.8***	72.1	133.9	82.4	**100-150**

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)
Description:
*) Has exceeded the water quality standard
**) Based on KP Regulation Number 75 of 2016
ST 3 = Shrimp Raising Pond Outlet
ST 4 = Outlet of Wastewater Treatment Plant (WWTP).

The results of the analysis of the Total Suspended Solid (TSS) parameter showed that the concentration values ranged from 1 mg/l – 40 mg/l. ST 1 in the analysis of water samples for 80 days was 4 mg/l and for 110 days was 7 mg/l. ST 2 in the first stage of the water sample analysis was 2 mg/l and in the second stage was 6 mg/l. At ST 3, the measurement of 80 days was at 16 mg/l and 110 days at 19 mg/l. ST 4 water sample analysis phase I was 22 mg/l and for 110 days was 40 mg/l. Therefore, the highest value was found in ST 4, namely 22 mg/l – 40 mg/l.

The pH parameter showed that at station 1, the measurement of 80 days was 7.83 and 110 days was 8.34; at station 2, the measurement of 80 days was 8.5 and 110 days was 8.56; at station 3, the measurement of 80 days was 8.01 and 110 days was 8.17; at station 4, the measurement of 80 days was 7.75 and 110 days was 8.12. Overall, the pH value of the water ranged from 7.75 to 8.56, which was still within the standard limits for source water and maintenance water.

The parameters of water salinity were: ST 1 at 80 days of measurement was 20.11‰ and 110 days was 24.36‰, while ST 2 at 80 days was 22.44‰ and 110 days was 25.13‰. ST 3 on the 80-day measurement was 21.28‰, and 110 days was 22.3‰, and then ST 4 on the 80-day measurement was 13.13% and 110 days was 13.57‰. Overall, the measurement of salinity of farm water and marine waters shows that the results were below the quality standards of source water and maintenance water, namely 26–32 promil, where the lowest concentration value was at station 4, namely the outlet of the shrimp farm WWTP.

Dissolved oxygen (DO) showed that it was still in accordance with the quality standards of source water and maintenance water (>4). At ST 1 (Inlet Tank) at 80 and 110 days, the results were 8.68 mg/l and 7.65 mg/l, respectively. At ST 2 (Outlet Reservoir), the analysis of water samples for 80 days was 7.89 mg/l and for 110 days was 7.25 mg/l. At ST 3 (shrimp rearing plots) at 80 days of 7.1 and 110 days of 5.64 mg/l, and the results of analysis of water samples at ST 4 (outlet of sewage treatment plant) at 80 days of 5.92 mg/l and 110 days at 4.43 mg/l, which was the lowest concentration value.

The BOD5 parameter was still below the quality standard for source and maintenance water, with a maximum concentration of 90 mg/l. The highest concentration was found in the analysis of water samples in ST 3 and 4 at the 80-day stage, which was 15.79 mg/l, while the lowest concentration was found in ST 2 in the analysis results of 80-day water samples, which was 0.39 mg/l.

Parameters of free ammonia (NH3-N) showed a concentration above the standard threshold for source and maintenance water of ≤ 0.1 mg/l, namely in the analysis of water samples in ST 1 at 80 days of 9,216 mg/l, 110 days of 2,370 mg/l. At ST 2, the analysis of 80-day water samples was 0.737 mg/l. At ST 3, 80 days of 14,093 mg/l and 110 days of 7,754 mg/l, and at ST 4, 80 days of 8,642 mg/l and 110 days of 5,472 mg/l. The concentration below the threshold was found at ST 2 in the analysis of water samples for 110 days of 0.047 mg/l. The pollution load of free ammonia waste at the outlet of shrimp cultivation farms (ST 3) produced 3.3 tons/ha/year, and the outlet of the wastewater treatment plant (WWTP) of shrimp farms (ST 4) which was discharged into coastal waters was 2.06 tons/ha/year.

The nitrite parameter with the highest concentration value was at ST 3 at 80 days at 0.608 mg/l and 110 days at 0.742 mg/l, and the lowest concentration value was at ST 2 at 80 days of water sample analysis at 0.002 mg/l. The nitrate parameter showed that the concentration value was above the standard threshold for source water and maintenance water of 0.5 mg/l, namely in ST 1 analysis of water samples for 110 days of 0.57 mg/l, ST 2 analysis of water samples for 80 days of 0.858 mg /l and 110 days of 0.51 mg/l, ST 3 analysis of 80-day water samples of 2.183 mg/l and 110 days of 2.49 mg/l, which were the highest concentration values, and ST 4 analysis of 80-day water samples of 1.951 mg/l and 110 days at 1.61 mg/l. Meanwhile, the concentration value below the maintenance water quality standard threshold was at station 1 of the 80-day water sample analysis of 0.293 mg/l, which was the lowest concentration value.

The pollution load of nitrate waste at the outlet of shrimp cultivation farms (ST 3) produced 555.97 kg/ha/year, and the outlet of the wastewater treatment plant (WWTP) of shrimp farms (ST 4) which was discharged into coastal waters was 475.96 kg/ha/year.

The phosphate parameter showed that at ST 1, the analysis of water samples for 80 days was 0.182 mg/l and for 110 days was <0.001 mg/l. At ST 2, the analysis of water samples for 80 days was 0.219 mg/l and <0.001 mg/l for 110 days. At ST 3, the analysis of water samples for 80 days was 1.886 mg/l

Commented [U4]: The author should explain how far the 4th Station is from the coastal waters. Does the route to the coastal waters pass through areas such as agriculture or housing? Did the authors consider the discharge of waste from other sources that contributed to the parameters studied? What is the argument/justification that the waste load does come from shrimp farming activities?`

and for 110 days was 1.355 mg/l. At ST 4, the analysis of water samples for 80 days was 3,434 mg/l, the highest concentration value, and for 110 days was 2,018 mg/l. Overall, at stations 1 – 4, the water quality parameters are in accordance with the quality standards of source water and maintenance water. The results of the analysis of the sulphide (H2S), Hg, Cd, and Pb parameters at ST 1, 2, 3, and 4 as a whole showed that the concentration value was not detected or below the water quality standard threshold that was set. Meanwhile, the Alkalinity parameter at station 3 of the 80-day water sample analysis showed a value above the quality standard of 164.8 mg/l from the quality standard ranging from 100-150 mg/l. On the other hand, at ST 1, the analysis of the 80-day water sample was 123.6 mg/l, and the 110-day stage was 140 mg/l; at ST 2, the analysis of the water sample for 80 days was 123.6 mg/l, and the 110-day stage was 92,7 mg/l. Finally, at ST 4, the analysis of water samples in the 80-day stage was 133.9 mg/l, and the 110-day stage was 82.4 mg/l, indicating that the concentration value was still in accordance with the established quality standards.

Measurement of the quality of coastal waters was carried out in coastal waters, as station 5 and marine waters 600 meters from the shoreline, as station 6. The results of in situ measurements and laboratory analysis are presented in Table 5.

Table 5. Coastal and marine water quality at 80 and 110 days of shrimp age

No	Parameter	**Unit**	St.5		St.6		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	30	30	29	29	**Coral: 28-30 seagrass: 28–30**
2	Brightness	meters	**2.7***	**3***	**2.78***	**3.12***	**corals: >5 Seagrass: >3**
3	TSS	mg/L	6	6	1	13	**Coral 20 seagrass 20**
4	pH	-	8.52	8.41	8.43	8.32	**7 – 8.5 (c)**
5	Salinity	%	**29.57***	**25.74***	**29.41***	**30.04***	**Coral: 33-34seagrass: 33 – 34**
6	Dissolved Oxygen (DO)	mg/L	7.89	7.65	7.89	7.65	**>5**
7	BOD	mg/L	1.97	0.81	0.39	0.4	**20**
8	Ammonia Free (NH3-N)	mg/L	**0.656***	**0.594***	0.294	0.107	**0.3**
9	Nitrite (NO2-N)	mg/L	0.257	0.009	0.006	0.018	**-**
10	Nitrate (NO3-N)	mg/L	**0.712***	**0.39***	**0.693***	**0.43***	**0.008**
11	Phosphate (PO4-P)	mg/L	**0.257***	**<0.001**	**0.162***	**0.091***	**0.015**
12	Sulphide (H2S)	mg/L	<0.01	<0.01	<0.01	<0.01	**0.01**
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	**0.001**
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**0.001**
15	Lead	mg/L	<0.0036	<0.0036	<0.00	<0.0036	**0.008**
16	Alkalinity	mg/L	92.7	103	82.4	103	**-**

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)

The results of the analysis of water quality parameters in coastal waters, which included coastal waters and marine waters 500 m from the coast were in coastal waters (ST 5) there was a concentration value of marine water parameters that have passed the threshold of marine water quality standards. In coastal waters (ST 5), there was a concentration of Free Ammonia (NH3-N) of 0.656 mg/l at 80 days and 0.594 mg/l at 110 days from marine water quality standards of 0.3 mg/l, Nitrate (NO3-N) with a concentration of 0.712 mg/l at 80 days and 0.39 mg/l at 110 days, and phosphate concentration (PO4-P) at 0.257 mg/l

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at 80 days. Meanwhile, in marine waters, there was a nitrate concentration of 0.693 mg/l at 80 days and 0.43 mg/l at 110 days, which has passed the marine water quality standard of 0.008 mg/l. The concentration of phosphate (PO4-P) of 0.162 mg/l at 80 days and 0.091 mg/l at 110 days have passed the marine water quality standard of 0.015 mg/l.
Observations of pollution in coastal waters were carried out in coastal waters and marine waters 600 meters from the shoreline, which were carried out in two sampling stages. In this method, each measured parameter would contribute to the Pollution Index (Pij) value.
The results of the calculation of the coastal water pollution index are presented in Table 6.

Table 6. Jembrana District Coastal Water Pollution Index in 2022

Score	St.5		St.6	
	80 days	110 days	80 days	110 days
Ci/Lix	23.82	36.29	31.81	27.89
Average Ci/Lix	1.49	2.27	1.99	1.74
Maximum Ci/Lix	10.75	15.52	10.70	9.65
Pij	**7.67**	**11.09**	**7.70**	**6.93**
Pollution Status	Moderate pollution	Heavy pollution	Moderate pollution	Moderate pollution

Source: Decree of the State Minister of the Environment Number 115 of 2003.

The results of the calculation of the pollution index of coastal waters are shown in Table 6. Coastal waters (ST 5) experienced moderate pollution at 80 days and became heavily polluted at 110 days. On the other hand, marine waters (ST 6) showed moderate contamination status both at 80 days and 100 days of the shrimp growth period.
Pollution in coastal areas occurs because the incoming waste exceeds the assimilation capacity of the coastal area and due to damage to the mangrove ecosystem, which is converted into agricultural land, fisheries, settlements and others so that the ability of the mangrove substrate to bind pollutants is reduced [9]. There are several parameters of the quality of wastewater from shrimp farms, such as Free Ammonia (NH3-N), Nitrate (NO3-N), and Phosphate (PO4-P) with concentration values that have passed the quality standards of source water and maintenance water as well as marine water for its biota.
Phosphate and nitrogen compounds such as ammonia, nitrate and nitrite contained in farms are metaboliteoxic and very dangerous for farm fisheries. Excess phosphate accompanied by nitrogen can stimulate the explosive growth of algae in the waters (algae bloom) [10]. The impact on shrimp-rearing activities is an increase in the abundance of pathogenic microorganisms (bacteria, protozoa, viruses) and an increase in the prevalence of shrimp disease. It will result in unsustainable shrimp cultivation [11].

Conclusions

1. The pollution load of shrimp farm waste based on the parameter concentration value has passed the quality standard of source water and maintenance water, namely: 1). Free ammonia (NH3-N) at ST 1, ST 2, ST 3, and ST 4; 2). Nitrate (NO3-N) at ST 1, ST 2, ST 3, and ST 4. A load of waste generated from shrimp rearing farms was free ammonia of 3.3 tons/ha/year and nitrate of 555.96 kg/ha/ year, while the pollution load of waste discharged into coastal waters from shrimp farm wastewater treatment plants was free ammonia of 2.06 tons/ha/year and nitrate of 475.96 kg/ha/year.
2. The pollution index of coastal waters in the shrimp cultivation area in Jembrana District was classified as moderately polluted with a Pij of 7.67 and heavily polluted (Pij = 11.09), respectively, at 80 days of observation and 110 days of shrimp rearing. Meanwhile, in marine waters, the pollution level was in the moderate category, both during the 80 days and 110 days of observation.

For shrimp cultivation and the preservation of the marine environment to be sustainable, it is necessary to analyse the capacity of the organic waste of shrimp farms on the carrying capacity of the marine environment, to be used as a reference in formulating policies for developing Vannamei shrimp cultivation areas in Jembrana District, Jembrana Regency.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

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References

[1] A Arifiani and Musadun , 2016. Study Community Perceptions of the Level of Sustainability of Coastal Areas Nest District . Regional and Environmental Journal : 4(03): 171-186.
[2] Aheto, D. W., Kankam, S., Okyere, I., Mensah, E., Osman, A., Jonah, F. E., & Mensah, J. C. 2016. Community based mangrove forest management: Implications for local livelihoods and coastal resource conservation along the Volta estuary catchment area of Ghana. Ocean & Coastal Management, 127, 43-54. doi:10.1016/j.ocecoaman.2016.04.006.
[3] Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325, 419-422. doi:10.1126/science.1172133
[4] Glaser, M., Christie, P., Diele, K., Dsikowitzky, L., Ferse, S., Nordhaus, I., . . . Wild, C. 2012. Measuring and understanding sustainability-enhancing processes in tropical coastal and marine social-ecological systems. Current Opinion in Environmental Sustainability, 4, 300-308. doi:10.1016/j.cosust.2012.05.004.
[5] Carlton, S. J., & Jacobson, S. K. 2013. Climate change and coastal environmental risk perceptions in Florida. Journal of Environmental Management, 130, 32-39. doi: 10.1016/j.jenvman.2013.08.038.
[6] Effendi, H, 2009. Review Water Quality ; For Management Source Power And Environment Waters , Yogyakarta: Kanisius .
[7] Supriyantini , E., Nuraini , RAT, & Fadmawati , AP (2017). Studies Content Ingredient Organics in Several River Estuaries in the Ecosystem Area . Bulletin Marina Oceanography , 6(1), 29–38
[8] Sodikin , S. 2012. Perception of the Farming Community pond To Sustainability Mangrove Forest in the Village Customs Ilir Subdistrict Pasakan Regency Indramayu . Journal Geography 12(1).
[9] Tohari , PAI, Suadi , S., & Subejo , S. (2020). Perception Cultivator Shrimp in Pond Business Development Continuing on the South Coast of the Special Region of Yogyakarta and Central Java . Journal Fisheries Gadjah Mada University , 22(1), 55-61.
[10] Harianja , RSM, Anita, S., & Mubarak, M. (2018). Pollution Load Analysis pond Shrimp Around the Bloated River Subdistrict Bantan Bengkalis . Dynamics Indonesian environment , 5(1), 12-19
[11] Paena , M., Syamsuddin , R., & Tandipayuk , H. (2020). Waste Load Estimation Organic From Ponds Shrimp Wasted Superintensive In Waters _ Bay Labuane . Journal Science and Technology marine Tropics , 12(2), 507-516.
[12] Lestari, I. (2021). Impact Waste organic pond Shrimp Super Intensive Vaname Against Eutrophication Rate Village Beach _ palalau Subdistrict Arungkeke Regency Jeneponto .

RESPONSE TO REVIEWS

Review	Responses
Page 1: The author should explain more about the description of waste water flow conditions in the coastal area	Page 1: Authors have added a brief explanation about the wastewater condition "The wastewater from the shrimp cultivation is treated in a wastewater treatment plant (WWTP) before it is discharged to the coast area. The WWTP's effluent quality adheres to national regulations for…………….."
Page 4:In this section, there should be more in-depth discussion of the findings in this study with previous similar findings.	Page 7: Authors have been added other similar findings "Research from Marinho-Soriano *et al.,* showing the characteristic of shrimp pond water quality during 0-75 days with average of TSS 138 mg/L, Dissolved oxygen 5,17 mg/L, salinity 35,83 PSU, pH 8,16, nitrate 0,195 mg/L, ammonium 2,73 mg/L, and phosphate 0,171 mg/L. *Gracilaria caudata J.* has been used to treat the wastewater to decrease the nutrient content. In 4 hours, the elimination of NH4-N was ……………….."
Page 5: Please explain how the WWTP system implementation at this location	Page 5: Authors have added brief explanation about the WWTP at the location "A shrimp farm's wastewater treatment system consumes 20% of the pond's capacity. It is made up of a pond for drying, a pond for equalizing, an aeration pond, and a pond for settling sediment. A screen is also added to the sedimentation pond to catch the tiny particles (1-2.5 mm) ……………."
Page 7: The author should explain how far the 4th Station is from the coastal waters. Does the route to the coastal waters pass through areas such as agriculture or housing? Did the authors consider the discharge of waste from other sources that contributed to the parameters studied? What is the argument/justification that the waste load does come from shrimp farming activities?	Page 7: Authors have added the brief information about ST 4 location and the discharge along the way to coastal area "The ST 4 is located about 1,5 km from the estuary or the coastal area. There are no community settlements or…………"

Table 5: In the table, it is better to add information /coloumns that explains each observation location and the quality standard/standard for the referenced parameters	Table 5: Authors have added the location of the station and quality standard are using

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Dear I Ketut Sumantra, Made Gede Soken, I Wayan Gde Wiryawan, I Made Wahyu Wijaya,

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RESEARCH ARTICLES

Marine Water Pollution Index in Intensive Shrimp Cultivation System in Jembrana

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Abstract Intensive shrimp cultivation with a high level of shrimp biomass and feeding will also result in high waste disposal. This condition can cause pollution in the surrounding waters and reduce the quality of the environment, which will threaten the sustainability of the environment and the sustainability of shrimp cultivation on the shrimp farm. The problem is the pollution load of shrimp farm wastes in the intensive cultivation system and the pollution status of coastal waters. This study aims to analyse the pollution load of shrimp farm wastes and the pollution status of coastal waters. This research was carried out in the coastal area of Jembrana District for four months, from March to June 2022. It was conducted by collecting data directly in the field. Samples were taken by purposive sampling method, namely at the inlet and outlet of the reservoir, the outlet of the shrimp farm, the outlet of the WWTP, coastal waters and marine waters. The pollution load level of shrimp farm waste at each station refers to the Minister of Environment Decree No. 54 of 2004, and the marine water pollution index refers to the Minister of Environment Decree No. 115 of 2003. The pollution load of shrimp farm waste based on the parameter concentration value has passed the thresholds for the quality standards of source water and maintenance water, which are: 1). Free ammonia (NH3-N) at ST 1, ST 2, ST 3, and ST 4; 2). Nitrate (NO3-N) at ST 1, ST 2, ST 3, and ST 4. A load of waste generated from shrimp rearing farms was free ammonia at 3.3 tons/ha/year and nitrate at 555.96 kg/ha/year. In contrast, the pollution load of waste discharged into coastal waters from shrimp farm wastewater treatment plants was free ammonia at 2.06 tons/ha/year and nitrate at 475.96 kg/ha/year. The pollution index of coastal waters in the shrimp farm cultivation area in Jembrana District was classified as moderately polluted with a Pij of 7.67 and heavily polluted (Pij = 11.09) according to 80 days of observation and 110 days of shrimp rearing. Meanwhile, in marine waters, the level of pollution was in the moderate category during the 80-day and 110-day observation periods. Maintaining the preservation of the marine environment requires an analysis of the capacity of the organic waste of shrimp farms on the carrying capacity of the aquatic environment. Therefore, it can be used as a reference in formulating policies for the development of Vannamei shrimp cultivation areas in Jembrana District, Jembrana Regency.

Keywords: Waters, marine, farm, pollution, shrimp, cultivation.

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Introduction

The Vannamei shrimp cultivation business has high economic value and potential in both local and international markets. This promising opportunity causes shrimp farmers to further increase their production due to the consideration of large profits. The farmers try their best to produce maximum business productivity, and one of the ways is by managing the farm business intensively with maximum stocking density and optimal feeding. In commercial aquaculture, as much as 30% of the total feed is not consumed by fish, and about 25%-30% of the consumed feed will be excreted [1]. The amount of nitrogen (N) and phosphorus (P) in the feed will be retained in the fish meat between 25%-30%, and the rest is wasted into the marine environment [2, 3]. An intensive shrimp cultivation system will cause input load in the form of shrimp feed into the cultivation media. It will lead to waste disposal of organic matter, toxic nitrogen nutrients and dissolved faeces into the waters. The impact that arises is water pollution and will reduce the quality of the environment. Water pollution affects the sustainability of shrimp cultivation in farms. Sources of water pollution can be derived from solids and dissolved forms. Solid forms include feed residues, fish faeces, and bacterial colonies, while dissolved forms include ammonia, urea, carbon dioxide, phosphorus, and hydrogen sulphide [4]. Such waste will increase with low feed conversion. The N and P retention of Vannamei shrimp feed in the rearing phase were 22.27% N and 9.79% P, respectively, so the nutrients wasted in the farm waters reached 77.73% N and 90.21% P, respectively [5]. Intensive exploitation of farms for shrimp cultivation not only harms coastal areas but also results in an unsustainable aquaculture industry [6]; [7]. Waste generally contains high Total Suspended Solid (TSS), phytoplankton and nutrients. The main nutrients found in shrimp farm cultivation waste are high levels of nitrogen and phosphorus [8], and the pH of the water is alkaline, pH 7-9 [9–11]. The amount of waste wasted in the form of N and P is largely determined by the farm's production capacity. The higher the farm production per unit area, the greater the N and P waste that is wasted into the waters [12]. This condition causes high concentrations of TSS, COD, BOD, total nitrate, and phosphate in coastal waters. The magnitude of the load of each of these parameters discharged into the waters from sequential aquaculture locations is: 3,533.3 kg/ha (TSS); 7,824.4 kg/ha (COD); 735.6 kg/ha (BOD); 167.8 kg/ha (total nitrate); and 3.0 kg/ha (total phosphate) [13, 14]. The results of the Vannamei shrimp disease surveillance in 2021 carried out by BKIPM Denpasar showed that in the shrimp farm area in Jembrana Regency, there had been an EHP (Enterocytozoon hepatorenal) disease attack with a spread rate of up to 100%. The disease attack occurs as an effect of waste disposal from shrimp farms. Therefore, shrimp farm wastewater to be discharged into the nearest water body must meet the applicable quality standards so as not to pollute local waters. The problem is how the pollution load of shrimp farm waste and the pollution status of coastal waters is due to the waste of the shrimp cultivation system dumped on the coast. The wastewater from the shrimp cultivation is treated in a wastewater treatment plant (WWTP) before it is discharged to the coast area. The WWTP's effluent quality adheres to national regulations for *Penaeus monodomus* and *Litopenaeus vanname* cultivation guidelines. Unfortunately, the effluent quality does not meet the quality threshold and putting the coastal environment at risk. Therefore, the research objectives are 1) to analyse the pollution load of shrimp farm waste; 2) to determine the pollution status of coastal waters due to intensive shrimp cultivation waste disposal.

Materials and Methods

Sampling wastewater quality from shrimp farms and coastal waters used the integrated sample method with purposive sampling, namely sampling in two shrimp farm units using intensive aquaculture technology. The sampling station locations were divided into six sampling stations. As for the location of the water sampling station, observations were made at two intensive shrimp farms and two coastal water locations as follows: 1). Unit 1 (ST.1A) and unit 2 (ST.1B) shrimp farm reservoir inlets, 2). Shrimp farm tank outlets unit 1 (ST.2A) and unit 2 (ST.2B), 3). Outlets of shrimp rearing farm unit 1 (ST.3A) and unit 2 (ST.3B), 4). Shrimp farm WWTP outlets unit 1 (ST.4A) and unit 2 (ST.4B), 5). Coastal Waters location 1 (ST.5A), location 2 (ST.5B), and 6). The marine water is 600 meters from the shoreline of location 1 (ST.6A) and location 2 (ST.6B) (Figure 1).

Figure 1. Sampling points from each station.

The samples that had been obtained were then analysed in the field and at the Health Laboratory of the Bali Provincial Health Office. The field and laboratory analysis results were used as guidelines for determining the pollution level from each research location. Water quality samples were observed in two stages: the first stage on 80-day-old shrimp and the second on 110-day-old shrimp.

Water quality data were analysed descriptively and compared with the quality standards of source water and maintenance water based on Ministerial Decree No. 75 of 2016 and marine water quality standards for marine biota according to Minister of Environment Decree No: 51 of 2004.

Table 1. Parameters and methods of water quality analysis

No	Parameter	Analysis Method	Measurement Place
a.	Physical Parameter		
	Temperature	Mercury thermometer	In situ
	TSS	Gravimetry	Laboratory
	Brightness	Secchi disc	In situ
b.	Chemical Parameter		
	pH	pH meters	In situ
	Salinity	Refractometer	In situ
	Dissolved oxygen	DO meters	In situ
	BOD	Electrometry	Laboratory
	Ammonia	Nessler	Laboratory
	Nitrate	Brucin	Laboratory
	Nitrite	Brucin	Laboratory
	Phosphate	Amm-Molybdate	Laboratory
	Heavy Metal: CD, Pb, Hg	AAS AAS Mercury Analyzer	Laboratory Laboratory Laboratory
	H2S	Spectrophotometry	Laboratory
	Alkalinity	Telemetry	Laboratory

The analysis of the pollution status of coastal waters in this study used the Pollution Index (PI) method based on the values of several water quality parameters that have been previously determined, namely the parameters of Temperature, Salinity, pH, O2, Alkalinity, BOD, Ammonia, Nitrite, Nitrate, Phosphate, Brightness, TSS, Heavy Metal, and H2S. Determination of the water quality status of coastal waters used the Pollution Index (IP) method of Coastal Waters by determining the status of water quality according to the Decree of the State Minister of the Environment, 2003, with the following formula:

$$Pij = \frac{\sqrt{(Cij/Lij)\ {}^{2}\mathrm{MCij}\ /\mathrm{Lij})^{2}\ R}}{2}$$

Where:
Lij = Concentration of water quality parameters listed in the quality standard of water designation (J)
Ci= Concentration of water quality parameters in the field
Pij= Pollution index for designation (J)
(Ci/Lij)R = value, Ci/Lij average
(Ci/Lij)M = value, maximum Ci/Lij

Table 2. Pollution Criteria

	Pollution Index	Description
1.	0 < Pij < 1.0	Meets quality standards (good condition)
2	1.0 < Pij < 5.0	Light pollution
3.	5.0 < Pij < 10	Moderate pollution
4.	Pij > 10	Heavy pollution

Source: Minister of Environment Decree No: 115, 2003

Results and Discussion

The shrimp cultivation system in Jembrana District is generally carried out using semi-intensive and intensive technology with a stocking density of 50-165 fish/m². The Vannamei shrimp cultivation system at the rearing stage starts from the preparation, maintenance and harvesting stages. At the preparation stage, several treatments are carried out, such as drying for two weeks, removing farm bottom mud, then liming the farm bottom at a dose of 1-2 tons/ha and in the maintenance process, a dose of 0.5 tons/ha. The next stage is filling the farm water to a height of 1.5 m to 1.7 m and leaving it for 15 days. Then the stocking of the fry is done in the morning or evening, which is first acclimatized for 15 minutes. The stocking density of fry in shrimp farms is 165 fish/m² with a size of PL 10. The feed given is in the form of artificial feed in the form of pellets with a nutritional composition of 38-40% protein, 12% water content, 6% fat and 3% fibre. The amount of feed given is based on the needs of the shrimp and is calculated based on the average weight gain with a frequency of feeding 2-5 times a day. Vannamei shrimp feeding based on age refers to SNI 01-7246 – 2006.

The management of shrimp farm water quality is carried out by collecting incoming water taken from the primary canal at high tide and then tamping it in a tendon plot for treatment and deposition after it is channelled to the enlargement farm plot. During the enlargement phase, water changes are carried out periodically every two days, as much as 10-15% starting from 15 days old shrimp and according to farm water conditions. Furthermore, the basic siphoning of the shrimp farms is carried out periodically to maintain water quality in order to be able to support the survival of the shrimp, which is carried out starting at the age of 15 days. After that, it is done gradually on day 5, day 3, and then every two days. Harvesting of Vannamei shrimp is done partially and totally. Partial harvesting is done to reduce the density so that shrimp growth is more optimal and avoids death due to disease. Partial harvesting is generally done on 60 days old shrimp and is situational. The total harvesting is done by harvesting the whole shrimp by draining the farm and storing it in a net at the disposal gate. It is done after the shrimp are 112 to 120 days old with a size of 35 (35 fish/kg). At the time of observation, the harvest was carried out in total when the shrimp reached 112 days of age with size 35 with an average individual weight of 29 grams/head. The survival rate is 90%, with an average yield of 25.6 tons per ha. The percentage of the amount of feed consumed by fish during the maintenance cycle to be converted into fish body weight with an average ratio of 1.3. Measurement of the quality of the source water in the shrimp farm reservoir was carried out at the inlet of the reservoir, designated as station 1 and the exit door of the shrimp farm (outlet), designated as station 2. The measurement results based on in situ measurements and laboratory analysis can be seen in Table 3.

Table 3. Water quality at the inlet and outlet of the reservoir at the age of 80 days and 110 days of shrimp

No	Parameter	Unit	St.1		St.2		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	30	30	30	30	**28 – 30**
2	Brightness	meters	0.5	0.5	0.5	0.5	**-**
3	TSS	mg/L	4	7	2	6	**-**
4	pH	-	8.54	7.83	8.56	8.5	**7.5-8.5**
5	Salinity	%	**24.36***	**20.11***	**22.44***	**25,13***	**26-32**
6	Dissolved Oxygen (DO)	mg/L	8.68	7.65	7.89	7.25	**> 4**
7	BOD	mg/L	1.97	0.4	0.39	2.01	□ **90**
8	Free Ammonia (NH3-N)	mg/L	**9,216***	**2,370**	**0.737***	0.047	□ **0.1**
9	Nitrite (NO2-N)	mg/L	0.008	0.004	0.002	0.009	□ **1**
10	Nitrate (NO3-N)	mg/L	0.293	**0.57***	**0.858***	**0.61***	**0.5**
11	Phosphate (PO4-P)	mg/L	0.182	<0.01	0.219	<0.001	**0.1-5**
12	Sulphide (H2S)	mg/L	<0.01	<0.01	<0.01	<0.01	□ **0.01**
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	**0.002**
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**0.01**
15	Timbal	mg/L	<0.0036	<0.0036	<0.0036	<0.0036	**0.03**
16	Alkalinity	mg/L	123.6	140	123.6	92.7	**100-150**

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)
Description:
*) Has exceeded the water quality standard
**) Based on KP Regulation Number 75 of 2016
ST 1: Inlet reservoir station
ST 2: Outlet reservoir station

The measurement of water temperature parameters at the study site ranged from 29ºC to 32ºC. The temperature ranges at stations 1 and 2 at 80 days and 110 days were still within the required quality standards, while at stations 3 and 4 at 80 and 110 days, measurements had exceeded the quality standards ranging from 31 - 32ºC. Based on the quality standards of source and maintenance water, the required temperature ranges from 27ºC to 30ºC.

The brightness of marine water at the study site at stations 1 and 2 is not required, while at station 3 (maintenance plot outlets) at 80 days measurement was 0.35 m, and at 110 days was 0.38 m, which was still in accordance with water quality standards for shrimp cultivation. On the other hand, at station 4 (outlet of the sewage treatment plant), at 80- and 110-days measurements was 0.25 m, which was below the quality standard for brightness, namely 0.3 - 0.5 m in source water and maintenance water.
Water quality measurement for the maintenance of Vannamei shrimp was carried out at the effluent gate of the enlargement farm as station 3 and the sluice gate of the wastewater treatment plant as station 4. A shrimp farm's wastewater treatment system consumes 20% of the pond's capacity. It is made up of a pond for drying, a pond for equalizing, an aeration pond, and a pond for settling sediment. A screen is also added to the sedimentation pond to catch the tiny particles (1-2.5 mm) that can't be seen. It should eliminate 40–60% of TSS from the effluent. By using mechanical aeration and a biofilter to encourage the growth of the microorganisms, the aeration pond was used to treat the BOD. Two aeration ponds are part of the shrimp farming operation. Based on how well each treatment unit got rid of contaminants, it was clear that the treatment wasn't enough to get rid of the contaminants in the wastewater. When the inlet and output parameters were compared, the removal efficiency for parameters BOD, free ammonia,

nitrate, and phosphate was less than 50%. The difficulty of increasing wastewater removal effectiveness persists.

Table 4. Water quality of enlargement farm outlets and WWTP outlets at the age of 80 and 110 days of shrimp

No	Parameter	Unit	St.3		St.4		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	31	31	32	32	>27
2	Brightness	meters	0.38	0.35	0.25	0.25	0.30-0.50
3	TSS	mg/L	16	19	22	40	-
4	pH	-	8.17	8.01	8.18	7.75	7.5-8.5
5	Salinity	%	21.28*	22.3*	13.13*	13.57*	26-32
6	Dissolved Oxygen (DO)	mg/L	7.1	5.64	5.92	4.43	> 4
7	BOD	mg/L	15.79	6.04	15.79	7.05	□ 90
8	Free Ammonia (NH3-N)	mg/L	14,098*	7,754*	8,642*	5,472*	□ 0.1
9	Nitrite (NO2-N)	mg/L	0.603	0.742	0.018	0.317	□ 1
10	Nitrate (NO3-N)	mg/L	2,183*	2.49*	1,951*	1.61*	0.5
11	Phosphate (PO4-P)	mg/L	1,886	1.355	3,434	2.018	0.1-5
12	Sulphide (H2S)	mg/L	<0.01	<0.01	<0.001	<0.01	< 0.01
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	0.002
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	0.01
15	Lead	mg/L	<0.0036	<0.0036	<0.0036	<0.0036	0.03
16	Alkalinity	mg/L	164.8*	72.1	133.9	82.4	100-150

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)
Description:
*) Has exceeded the water quality standard
**) Based on KP Regulation Number 75 of 2016
ST 3 = Shrimp Raising Pond Outlet
ST 4 = Outlet of Wastewater Treatment Plant (WWTP).

The results of the analysis of the Total Suspended Solid (TSS) parameter showed that the concentration values ranged from 1 mg/l – 40 mg/l. ST 1 in the analysis of water samples for 80 days was 4 mg/l and for 110 days was 7 mg/l. ST 2 in the first stage of the water sample analysis was 2 mg/l and in the second stage was 6 mg/l. At ST 3, the measurement of 80 days was at 16 mg/l and 110 days at 19 mg/l. ST 4 water sample analysis phase I was 22 mg/l and for 110 days was 40 mg/l. Therefore, the highest value was found in ST 4, namely 22 mg/l – 40 mg/l.

The pH parameter showed that at station 1, the measurement of 80 days was 7.83 and 110 days was 8.34; at station 2, the measurement of 80 days was 8.5 and 110 days was 8.56; at station 3, the measurement of 80 days was 8.01 and 110 days was 8.17; at station 4, the measurement of 80 days was 7.75 and 110 days was 8.12. Overall, the pH value of the water ranged from 7.75 to 8.56, which was still within the standard limits for source water and maintenance water.

The parameters of water salinity were: ST 1 at 80 days of measurement was 20.11‰ and 110 days was 24.36‰, while ST 2 at 80 days was 22.44‰ and 110 days was 25.13‰. ST 3 on the 80-day measurement was 21.28‰, and 110 days was 22.3‰, and then ST 4 on the 80-day measurement was 13.13% and 110 days was 13.57‰. Overall, the measurement of salinity of farm water and marine waters shows that the results were below the quality standards of source water and maintenance water, namely 26–32 promil, where the lowest concentration value was at station 4, namely the outlet of the shrimp farm WWTP.

Dissolved oxygen (DO) showed that it was still in accordance with the quality standards of source water and maintenance water (>4). At ST 1 (Inlet Tank) at 80 and 110 days, the results were 8.68 mg/l and 7.65 mg/l, respectively. At ST 2 (Outlet Reservoir), the analysis of water samples for 80 days was 7.89 mg/l and for 110 days was 7.25 mg/l. At ST 3 (shrimp rearing plots) at 80 days of 7.1 and 110 days of 5.64 mg/l, and the results of analysis of water samples at ST 4 (outlet of sewage treatment plant) at 80 days of 5.92 mg/l and 110 days at 4.43 mg/l, which was the lowest concentration value.

The BOD5 parameter was still below the quality standard for source and maintenance water, with a maximum concentration of 90 mg/l. The highest concentration was found in the analysis of water samples in ST 3 and 4 at the 80-day stage, which was 15.79 mg/l, while the lowest concentration was found in ST 2 in the analysis results of 80-day water samples, which was 0.39 mg/l.

Parameters of free ammonia (NH3-N) showed a concentration above the standard threshold for source and maintenance water of ≤ 0.1 mg/l, namely in the analysis of water samples in ST 1 at 80 days of 9,216 mg/l, 110 days of 2,370 mg/l. At ST 2, the analysis of 80-day water samples was 0.737 mg/l. At ST 3, 80 days of 14,093 mg/l and 110 days of 7,754 mg/l, and at ST 4, 80 days of 8,642 mg/l and 110 days of 5,472 mg/l. The concentration below the threshold was found at ST 2 in the analysis of water samples for 110 days of 0.047 mg/l. The pollution load of free ammonia waste at the outlet of shrimp cultivation farms (ST 3) produced 3.3 tons/ha/year, and the outlet of the wastewater treatment plant (WWTP) of shrimp farms (ST 4) which was discharged into coastal waters was 2.06 tons/ha/year.

The nitrite parameter with the highest concentration value was at ST 3 at 80 days at 0.608 mg/l and 110 days at 0.742 mg/l, and the lowest concentration value was at ST 2 at 80 days of water sample analysis at 0.002 mg/l. The nitrate parameter showed that the concentration value was above the standard threshold for source water and maintenance water of 0.5 mg/l, namely in ST 1 analysis of water samples for 110 days of 0.57 mg/l, ST 2 analysis of water samples for 80 days of 0.858 mg /l and 110 days of 0.51 mg/l, ST 3 analysis of 80-day water samples of 2.183 mg/l and 110 days of 2.49 mg/l, which were the highest concentration values, and ST 4 analysis of 80-day water samples of 1.951 mg/l and 110 days at 1.61 mg/l. Meanwhile, the concentration value below the maintenance water quality standard threshold was at station 1 of the 80-day water sample analysis of 0.293 mg/l, which was the lowest concentration value. The pollution load of nitrate waste at the outlet of shrimp cultivation farms (ST 3) produced 555.97 kg/ha/year, and the outlet of the wastewater treatment plant (WWTP) of shrimp farms (ST 4) which was discharged into coastal waters was 475.96 kg/ha/year. The ST 4 is located about 1,5 km from the estuary or the coastal area. There are no community settlements or industrial discharges along the route to the coast. It means the discharged from shrimp cultivation are the majority contributor of the wastewater in the coastal area.

The phosphate parameter showed that at ST 1, the analysis of water samples for 80 days was 0.182 mg/l and for 110 days was <0.001 mg/l. At ST 2, the analysis of water samples for 80 days was 0.219 mg/l and <0.001 mg/l for 110 days. At ST 3, the analysis of water samples for 80 days was 1.886 mg/l and for 110 days was 1.355 mg/l. At ST 4, the analysis of water samples for 80 days was 3,434 mg/l, the highest concentration value, and for 110 days was 2,018 mg/l. Overall, at stations 1 – 4, the water quality parameters are in accordance with the quality standards of source water and maintenance water. The results of the analysis of the sulphide (H2S), Hg, Cd, and Pb parameters at ST 1, 2, 3, and 4 as a whole showed that the concentration value was not detected or below the water quality standard threshold that was set. Meanwhile, the Alkalinity parameter at station 3 of the 80-day water sample analysis showed a value above the quality standard of 164.8 mg/l from the quality standard ranging from 100-150 mg/l. On the other hand, at ST 1, the analysis of the 80-day water sample was 123.6 mg/l, and the 110-day stage was 140 mg/l; at ST 2, the analysis of the water sample for 80 days was 123.6 mg/l, and the 110-day stage was 92,7 mg/l. Finally, at ST 4, the analysis of water samples in the 80-day stage was 133.9 mg/l, and the 110-day stage was 82.4 mg/l, indicating that the concentration value was still in accordance with the established quality standards. Research from Marinho-Soriano *et al.,* showing the characteristic of shrimp pond water quality during 0-75 days with average of TSS 138 mg/L, Dissolved oxygen 5,17 mg/L, salinity 35,83 PSU, pH 8,16, nitrate 0,195 mg/L, ammonium 2,73 mg/L, and phosphate 0,171 mg/L. *Gracilaria caudata J.* has been used to treat the wastewater to decrease the nutrient content. In 4 hours, the elimination of NH4-N was approximately 59.5%, NO3-N 49.6%, and PO4-P 12.3%. These findings suggest that, despite their relatively slow growth rates, G. caudata can be farmed alongside shrimp and contribute to the removal of nitrogen and phosphorus from the pond [15]. Satanwat et al. used a fibrous biofilter to improve water quality in a shrimp cultivation tank by managing the nitrification and denitrification processes. Because of the use of pre-acclimated fibrous material, some denitrification occurred concurrently with nitrification during the shrimp cultivation period. During the 150-day operation period, the NRs of Biocord ranged between 17.1 12.4 and 112.3 50.2 mg-N/m2/d. DNRs of 117.6 34.0 and 119.1 8.35 g-N/m3/d were observed under anoxic conditions with an external carbon supplement after adjusting to a suitable environment [16].

Measurement of the quality of coastal waters was carried out in coastal waters, as station 5 and marine waters 600 meters from the shoreline, as station 6. The results of in situ measurements and laboratory analysis are presented in Table 5.

Table 5. Coastal and marine water quality at 80 and 110 days of shrimp age

No	Parameter	Unit	St.5 (Coastal area)		St.6 (Sea water)		Quality Standard **)
			80 days	110 days	80 days	110 days	
1	Temperature	C	30	30	29	29	**Coral: 28-30 seagrass: 28–30**
2	Brightness	meters	**2.7***	**3***	**2.78***	**3.12***	**corals: >5 Seagrass: >3**
3	TSS	mg/L	6	6	1	13	**Coral 20 seagrass 20**
4	pH	-	8.52	8.41	8.43	8.32	**7 – 8.5 (c)**
5	Salinity	%	**29.57***	**25.74***	**29.41***	**30.04***	**Coral: 33-34 seagrass: 33 – 34**
6	Dissolved Oxygen (DO)	mg/L	7.89	7.65	7.89	7.65	**>5**
7	BOD	mg/L	1.97	0.81	0.39	0.4	**20**
8	Ammonia Free (NH3-N)	mg/L	**0.656***	**0.594***	0.294	0.107	**0.3**
9	Nitrite (NO2-N)	mg/L	0.257	0.009	0.006	0.018	**-**
10	Nitrate (NO3-N)	mg/L	**0.712***	**0.39***	**0.693***	**0.43***	**0.008**
11	Phosphate (PO4-P)	mg/L	**0.257***	**<0.001**	**0.162***	**0.091***	**0.015**
12	Sulphide (H2S)	mg/L	<0.01	<0.01	<0.01	<0.01	**0.01**
13	Mercury (Hg)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	**0.001**
14	Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**0.001**
15	Lead	mg/L	<0.0036	<0.0036	<0.00	<0.0036	**0.008**
16	Alkalinity	mg/L	92.7	103	82.4	103	**-**

Source: Health Laboratory Analysis, Bali Provincial Health Office (2022)

The results of the analysis of water quality parameters in coastal waters, which included coastal waters and marine waters 500 m from the coast were in coastal waters (ST 5) there was a concentration value of marine water parameters that have passed the threshold of marine water quality standards. In coastal waters (ST 5), there was a concentration of Free Ammonia (NH3-N) of 0.656 mg/l at 80 days and 0.594 mg/l at 110 days from marine water quality standards of 0.3 mg/l, Nitrate (NO3-N) with a concentration of 0.712 mg/l at 80 days and 0.39 mg/l at 110 days, and phosphate concentration (PO4-P) at 0.257 mg/l at 80 days. Meanwhile, in marine waters, there was a nitrate concentration of 0.693 mg/l at 80 days and

0.43 mg/l at 110 days, which has passed the marine water quality standard of 0.008 mg/l. The concentration of phosphate (PO4-P) of 0.162 mg/l at 80 days and 0.091 mg/l at 110 days have passed the marine water quality standard of 0.015 mg/l.

Observations of pollution in coastal waters were carried out in coastal waters and marine waters 600 meters from the shoreline, which were carried out in two sampling stages. In this method, each measured parameter would contribute to the Pollution Index (Pij) value.

The results of the calculation of the coastal water pollution index are presented in Table 6.

Table 6. Jembrana District Coastal Water Pollution Index in 2022

Score	St.5		St.6	
	80 days	**110 days**	**80 days**	**110 days**
Ci/Lix	23.82	36.29	31.81	27.89
Average Ci/Lix	1.49	2.27	1.99	1.74
Maximum Ci/Lix	10.75	15.52	10.70	9.65
Pij	**7.67**	**11.09**	**7.70**	**6.93**
Pollution Status	Moderate pollution	Heavy pollution	Moderate pollution	Moderate pollution

Source: Decree of the State Minister of the Environment Number 115 of 2003.

The results of the calculation of the pollution index of coastal waters are shown in Table 6. Coastal waters (ST 5) experienced moderate pollution at 80 days and became heavily polluted at 110 days. On the other hand, marine waters (ST 6) showed moderate contamination status both at 80 days and 100 days of the shrimp growth period.

Pollution in coastal areas occurs because the incoming waste exceeds the assimilation capacity of the coastal area and due to damage to the mangrove ecosystem, which is converted into agricultural land, fisheries, settlements and others so that the ability of the mangrove substrate to bind pollutants is reduced [9]. There are several parameters of the quality of wastewater from shrimp farms, such as Free Ammonia (NH3-N), Nitrate (NO3-N), and Phosphate (PO4-P) with concentration values that have passed the quality standards of source water and maintenance water as well as marine water for its biota.

Phosphate and nitrogen compounds such as ammonia, nitrate and nitrite contained in farms are metaboliteoxic and very dangerous for farm fisheries. Excess phosphate accompanied by nitrogen can stimulate the explosive growth of algae in the waters (algae bloom) [10[17–19]]. The impact on shrimp-rearing activities is an increase in the abundance of pathogenic microorganisms (bacteria, protozoa, viruses) and an increase in the prevalence of shrimp disease. It will result in unsustainable shrimp cultivation [20, 21].

Conclusions

1. The pollution load of shrimp farm waste based on the parameter concentration value has passed the quality standard of source water and maintenance water, namely: 1). Free ammonia (NH3-N) at ST 1, ST 2, ST 3, and ST 4; 2). Nitrate (NO3-N) at ST 1, ST 2, ST 3, and ST 4. A load of waste generated from shrimp rearing farms was free ammonia of 3.3 tons/ha/year and nitrate of 555.96 kg/ha/ year, while the pollution load of waste discharged into coastal waters from shrimp farm wastewater treatment plants was free ammonia of 2.06 tons/ha/year and nitrate of 475.96 kg/ha/year.
2. The pollution index of coastal waters in the shrimp cultivation area in Jembrana District was classified as moderately polluted with a Pij of 7.67 and heavily polluted (Pij = 11.09), respectively, at 80 days of observation and 110 days of shrimp rearing. Meanwhile, in marine waters, the pollution level was in the moderate category, both during the 80 days and 110 days of observation.

For shrimp cultivation and the preservation of the marine environment to be sustainable, it is necessary to analyse the capacity of the organic waste of shrimp farms on the carrying capacity of the marine environment, to be used as a reference in formulating policies for developing Vannamei shrimp cultivation areas in Jembrana District, Jembrana Regency.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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References

[1] Arifiani, N. A., Mussadun, M. (2016). Studi persepsi masyarakat terhadap tingkat keberlanjutan Wilayah Pesisir Kecamatan Sarang. *Jurnal Wilayah dan Lingkungan, 4*, 171.

[2] Aheto, D. W., Kankam, S., Okyere, I., Mensah, E., Osman, A., Jonah, F. E., Mensah, J. C. (2016). Community-based mangrove forest management: Implications for local livelihoods and coastal resource conservation along the Volta estuary catchment area of Ghana. *Ocean Coast Manag., 127*, 43-54.

[3] Yang, X. E., Wu, X., Hao, H. L., He, Z. L. (2008). Mechanisms and assessment of water eutrophication. *J Zhejiang Univ Sci B*, *9*, 197-209

[4] Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, *325*, 419-422.

[5] Glaser, M., Christie, P., Diele, K., Dsikowitzky, L., Ferse, S., Nordhaus, I., Schlüter, A., Schwerdtner Mañez, K., Wild, C. (2012). Measuring and understanding sustainability-enhancing processes in tropical coastal and marine social-ecological systems. *Curr Opin Environ Sustain., 4*, 300-308

[6] Carlton, S. J., Jacobson, S. K. (2013). Climate change and coastal environmental risk perceptions in Florida. *J Environ Manage, 130*, 32-39.

[7] Putri, D. W., Soewondo, P., Effendi, A. J., Setiadi, T. (2017). Sustainability analysis of domestic astewater treatment technology applied on human settlement in swamp area. *Int J Sci Eng Res, 7*, 5w4-66.

[8] Supriyantini, E., Nuraini, R. A. T., Fadmawati, A. P. (2017). Studi Kandungan Bahan Organik Pada Beberapa Muara Sungai Di Kawasan Ekosistem Mangrove, Di Wilayah Pesisir Pantai Utara Kota Semarang, Jawa Tengah. *Buletin Oseanografi Marina, 6*, 29-38.

[9] Sodikin, S. (2016). Persepsi Masyarakat Petani Tambak Terhadap Kelestarian Hutan Mangrove Di Desa Pabean Ilir Kecamatan Pasekan Kabupaten Indramayu. *Jurnal Geografi Gea.* https://doi.org/10.17509/gea.v12i1.2597.

[10] Eriksson, E., Eriksson, E., Auffarth, K., Henze, M., Ledin, A. (2016). Characteristics of grey wastewater characteristics of grey wastewater, 0758:85–104.

[11] Lozano, S., Garrett, M. J., Zhang, Y., *et al*. (2014). Primer for municipal wastewater treatment systems. Master thesis, *22*, 55.

[12] Iman Tohari, P. A., Suadi, S., Subejo, S. (2020). Persepsi pembudidaya udang dalam pengembangan usaha tambak berkelanjutan di Pantai Selatan Daerah Istimewa Yogyakarta dan Jawa Tengah. *Jurnal Perikanan Universitas Gadjah Mada*, *22*, :55.

[13] Harianja, R. S. M., Anita, S., Mubarak, M. (2018). Analisis beban pencemaran tambak udang di sekitar Sungai Kembung Kecamatan Bantan Bengkalis. *Dinamika Lingkungan Indonesia*, *5*, 12-19.

[14] Akpor, O. B., Muchie, M. (2011). Environmental and public health implications of wastewater quality. *Afr J Biotechnol,10*, 2379-2387.

[15] Marinho-Soriano, E., Panucci, R. A., Carneiro, M. A. A., Pereira, D. C. (2009). Evaluation of Gracilaria caudata J. Agardh for bioremediation of nutrients from shrimp farming wastewater. *Bioresour Technol, 100,* 192-6198.

[16] Satanwat, P., Tran, T. P., Hirakata, Y., Watari, T., Hatamoto, M., Yamaguchi, T., Pungrasmi, W., Powtongsook, S. (2020). Use of an internal fibrous biofilter for intermittent nitrification and denitrification treatments in a zero-discharge shrimp culture tank. *Aquac Eng.*

https://doi.org/10.1016/j.aquaeng.2019.102041.
[17] Wijaya, I. Made Wahyu, Soedjono, E. S. (2018). Physicochemical characteristic of municipal wastewater in tropical area: case study of Surabaya City, Indonesia. *IOP Conf Series: Earth and Environmental Science.* https://doi.org/doi :10.1088/1755-1315/135/1/012018.
[18] Wahyu Wijaya, I. M. (2019). The strategies to reduce the spread of nitrogen from domestic wastewater treatment to the streams in Surabaya City, Indonesia. *International Journal of GEOMATE*, *16*, 204-210.
[19] Wijaya, I. M. W., Soedjono, E. S. (2018). Domestic wastewater in Indonesia: Challenge in the future related to nitrogen content. *International Journal of GEOMATE*, *15*, 1.
[20] Paena, M., Syamsuddin, R., Rani, C., Tandipayuk, H. (2020) Estimasi beban limbah organik dari tambak udang superintensif yang terbuang di Perairan Teluk Labuange. *Jurnal Ilmu dan Teknologi Kelautan Tropis, 12*, 509-518.
[21] Sun, Y., Chen, Z., Wu, G., Wu, Q., Zhang, F., Niu, Z., Hu, H. Y. (2016). Characteristics of water quality of municipal wastewater treatment plants in China: Implications for resources utilization and management. *J Clean Prod., 131*, 1–9.

Marine Water Pollution Index in Intensive Shrimp Cultivation System in Jembrana

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Abstract

Intensive shrimp cultivation with a high level of shrimp biomass and feeding will also result in high waste disposal. This condition can cause pollution in the surrounding waters and reduce the quality of the environment, which will threaten the sustainability of the environment and the sustainability of shrimp cultivation on the shrimp farm. The problem is the pollution load of shrimp farm wastes in the intensive cultivation system and the pollution status of coastal waters. This study aims to analyse the pollution load of shrimp farm wastes and the pollution status of coastal waters. This research was carried out in the coastal area of Jembrana District for four months, from March to June 2022. It was conducted by collecting data directly in the field. Samples were taken by purposive sampling method, namely at the inlet and outlet of the reservoir, the outlet of the shrimp farm, the outlet of the WWTP, coastal waters and marine waters. The pollution load level of shrimp farm waste at each station refers to the Minister of Environment Decree No. 54 of 2004, and the marine water pollution index refers to the Minister of Environment Decree No. 115 of 2003. The pollution load of shrimp farm waste based on the parameter concentration value has passed the thresholds for the quality standards of source water and maintenance water, which are: 1). Free ammonia (NH3-N) at ST 1, ST 2, ST 3, and ST 4; 2). Nitrate (NO3-N) at ST 1, ST 2, ST 3, and ST 4. A load of waste generated from shrimp rearing farms was free ammonia at

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3.3 tons/ha/year and nitrate at 555.96 kg/ha/year. In contrast, the pollution load of waste discharged into coastal waters from shrimp farm wastewater treatment plants was free ammonia at 2.06 tons/ha/year and nitrate at 475.96 kg/ha/year. The pollution index of coastal waters in the shrimp farm cultivation area in Jembrana District was classified as moderately polluted with a Pij of 7.67 and heavily polluted (Pij = 11.09) according to 80 days of observation and 110 days of shrimp rearing. Meanwhile, in marine waters, the level of pollution was in the moderate category during the 80-day and 110-day observation periods. Maintaining the preservation of the marine environment requires an analysis of the capacity of the organic waste of shrimp farms on the carrying capacity of the aquatic environment. Therefore, it can be used as a reference in formulating policies for the development of Vannamei shrimp cultivation areas in Jembrana District, Jembrana Regency.

References

Arifiani, N. A., Mussadun, M. (2016). Studi persepsi masyarakat terhadap tingkat keberlanjutan Wilayah Pesisir Kecamatan Sarang. Jurnal Wilayah dan Lingkungan, 4, 171.

Aheto, D. W., Kankam, S., Okyere, I., Mensah, E., Osman, A., Jonah, F. E., Mensah, J. C. (2016). Community-based mangrove forest management: Implications for local livelihoods and coastal resource conservation along the Volta estuary catchment area of Ghana. Ocean Coast Manag., 127, 43-54.

Yang, X. E., Wu, X., Hao, H. L., He, Z. L. (2008). Mechanisms and assessment of water eutrophication. J Zhejiang Univ Sci B, 9, 197-209

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325, 419-422.

Glaser, M., Christie, P., Diele, K., Dsikowitzky, L., Ferse, S., Nordhaus, I., Schlüter, A., Schwerdtner Mañez, K., Wild, C. (2012). Measuring and understanding sustainability-enhancing processes in tropical coastal and marine social-ecological systems. Curr Opin Environ Sustain., 4, 300-308

Carlton, S. J., Jacobson, S. K. (2013). Climate change and coastal environmental risk perceptions in Florida. J Environ Manage, 130, 32-39.

Putri, D. W., Soewondo, P., Effendi, A. J., Setiadi, T. (2017). Sustainability analysis of domestic astewater treatment technology applied on human settlement in swamp area. Int J Sci Eng Res, 7, 5w4-66.

Supriyantini, E., Nuraini, R. A. T., Fadmawati, A. P. (2017). Studi Kandungan Bahan Organik Pada Beberapa Muara Sungai Di Kawasan Ekosistem Mangrove, Di Wilayah Pesisir Pantai Utara Kota Semarang, Jawa Tengah. Buletin Oseanografi Marina, 6, 29-38.

Sodikin, S. (2016). Persepsi Masyarakat Petani Tambak Terhadap Kelestarian Hutan Mangrove Di Desa Pabean Ilir Kecamatan Pasekan Kabupaten Indramayu. Jurnal Geografi Gea. https://doi.org/10.17509/gea.v12i1.2597.

Eriksson, E., Eriksson, E., Auffarth, K., Henze, M., Ledin, A. (2016). Characteristics of grey wastewater characteristics of grey wastewater, 0758:85–104.

Lozano, S., Garrett, M. J., Zhang, Y., et al. (2014). Primer for municipal wastewater treatment systems. Master thesis, 22, 55.

Iman Tohari, P. A., Suadi, S., Subejo, S. (2020). Persepsi pembudidaya udang dalam pengembangan usaha tambak berkelanjutan di Pantai Selatan Daerah Istimewa Yogyakarta dan Jawa Tengah. Jurnal Perikanan Universitas Gadjah Mada, 22, :55.

Harianja, R. S. M., Anita, S., Mubarak, M. (2018). Analisis beban pencemaran tambak udang di sekitar Sungai Kembung Kecamatan Bantan Bengkalis. Dinamika Lingkungan Indonesia, 5, 12-19.

Akpor, O. B., Muchie, M. (2011). Environmental and public health implications of wastewater quality. Afr J Biotechnol,10, 2379-2387.

Marinho-Soriano, E., Panucci, R. A., Carneiro, M. A. A., Pereira, D. C. (2009). Evaluation of Gracilaria caudata J. Agardh for bioremediation of nutrients from shrimp farming wastewater. Bioresour Technol, 100, 192-6198.

Satanwat, P., Tran, T. P., Hirakata, Y., Watari, T., Hatamoto, M., Yamaguchi, T., Pungrasmi, W., Powtongsook, S. (2020). Use of an internal fibrous biofilter for intermittent nitrification and denitrification treatments in a zero-discharge shrimp culture tank. Aquac Eng. https://doi.org/10.1016/j.aquaeng.2019.102041.

Wijaya, I. Made Wahyu, Soedjono, E. S. (2018). Physicochemical characteristic of municipal wastewater in tropical area: case study of Surabaya City, Indonesia. IOP Conf Series: Earth and Environmental Science. https://doi.org/doi :10.1088/1755-1315/135/1/012018.

Wahyu Wijaya, I. M. (2019). The strategies to reduce the spread of nitrogen from domestic wastewater treatment to the streams in Surabaya City, Indonesia. International Journal of GEOMATE, 16, 204-210.

Wijaya, I. M. W., Soedjono, E. S. (2018). Domestic wastewater in Indonesia: Challenge in the future related to nitrogen content. International Journal of GEOMATE, 15, 1.

Paena, M., Syamsuddin, R., Rani, C., Tandipayuk, H. (2020) Estimasi beban limbah organik dari tambak udang superintensif yang terbuang di Perairan Teluk Labuange. Jurnal Ilmu dan Teknologi Kelautan Tropis, 12, 509-518.

Sun, Y., Chen, Z., Wu, G., Wu, Q., Zhang, F., Niu, Z., Hu, H. Y. (2016). Characteristics of water quality of municipal wastewater treatment plants in China: Implications for resources utilization and management. J Clean Prod., 131, 1–9.

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