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Pollution Charges and Assimilation Capacity in Tanjungpinang Bay Area, Riau Islands Province, Indonesia

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Abstract: The Tanjungpinang bay at Riau Islands Province is one of coastal areas that have a high level pollution load due to the increased scale of economic activities and also rapid community activities are increased dynamically. Hence carrying out a research which aim for knowing the pollution load and the assimilation capacity determination in Tanjungpinang bay area have a very strategic position. This study is based on survey method through the observation techniques in the field for distinguishing variables with the parameters set by purposive sampling. The data were analyzed to produce the charts which describe the relationship between each parameter with the total pollution load in estuaries. The results explain the pollution load into the Tanjungpinang bay area which includes parameters of TSS, BOD_5, COD, NO_3, NO_2, NH_4 and PO_4-P respectively amounted to 397.369 tons/year, 20.858 tons/year, 791 079 tons/year, 1.156 tons/year, 824 tons/year, 1.115 tons/year and 606 tons/year. While the Tanjungpinang bay area assimilation capacity for each parameter above amounted to 689 960 tons/year, 67.062 tons/year, 640.930 tons/year, –89 tones/year, –9 tons/year, 1.145 tons/year and –12 tons/year. This shows that the pollution load to the parameters COD, NO_3, NO_2 and PO_4-P has exceeded the carrying capacity of the waters.

Key words: Pollution load, assimilation capacity of the waters, the Tanjungpinang bay area.

Introduction

Waters on the bay area is one of marine coastal environment which are much influenced by pollutant discharges either from land or from the open sea. Buildup of waste can ultimately lead to contamination. According to Schaffelke et al. (2005), most of the pollutants as much as 80% of waste found at sea comes from human activities on land (land based activities), with the rest of the activities in the sea.

The high rate of population growth increased which brings influence to the urbanization as a result of the economic improvement on islands and urban development in coastal areas of small islands caused a significant population increase annually. The increase in population will affect the extra burden of solid waste and liquid waste discharged into the environment as a byproduct of the activities of urban population. Contribution of organic pollutants by liquid waste from man reported to have reached 50% to 75% of total liquid waste (Russo, 2002). The situation provides an enormous pressure on the environment of coastal waters, especially in environmental degradation.

In the tropics, increasing discharge pollutants into waters of the bay sourced from terrestrial land (land-based) continues (Wilkinson, 2012). 65% of organic

waste is released from the river into the coastal waters. Disposal of waste into the environment of coastal waters causes water pollution, resulting in disruption of the balance of aquatic systems. Duda (2006) described the negative impact of environmental degradation caused by pollution of waters which can cause economic losses and ecological aquatic biological form of reduced productivity, damage to aquatic ecosystems and decreased aesthetic value, and can endanger human health.

The contamination of organic waste has increased along with the increase in population of Tanjungpinang coastal area , it needed some information about the condition of the aquatic environment which describes the amount of pollution load and carrying capacity of the receiving waters of pollutants that enter into such waters. Thus, the study aims to determine the pollution load of organic wastes that enter aquatic environments and determine the level of assimilation capacity of the receiving waters of the Tanjungpinang bay area contaminants.

Materials and Methods

Location Research

The research location is set in the Tanjungpinang bay, while the sampling sites were chosen to represent the community activities on land and in the water which are the source of the pollution. Based on these considerations, the sampling locations are specified in river flows with a distance range of 500 and 1000 metres from the mouth of the river and in the waters on Tanjungpinang bay area at Riau IslandsProvince, Indonesia (Figure 1).

Methods

The method of collecting data in the field is done by intentionally (purposive) sampling based on the location of waste disposal that goes into the waters of the Gulf of Tanjungpinang. The data collection technique for water sampling was done two times during high tide and low tide using Nansen bottles. Then the water samples were inserted into the bottles and kept in a cold labelled box and treated in accordance with the parameters to be analyzed in the laboratory.

The pollution load, which comes from fields onshore go into the waters of the bay area, is calculated through the direct measurement of the concentration of pollution parameters at each observation station. Method of calculating pollution load contained in the waters multiplication is formulated on the basis of river discharge (m^3/s) with pollutant concentrations (mg/L) using the equation (Mitsch and Goesselink, 1993):

$$Bp = Q \,.\, Ci$$

where Bp = pollution load which comes from one river (mg/s), Q = water of the river discharge (L/s) and Ci = concentration of parameters to the pollutant-i (mg/L).

Total pollution load of the entire river which empties into the waters on Tanjungpinang bay area is calculated by the equation:

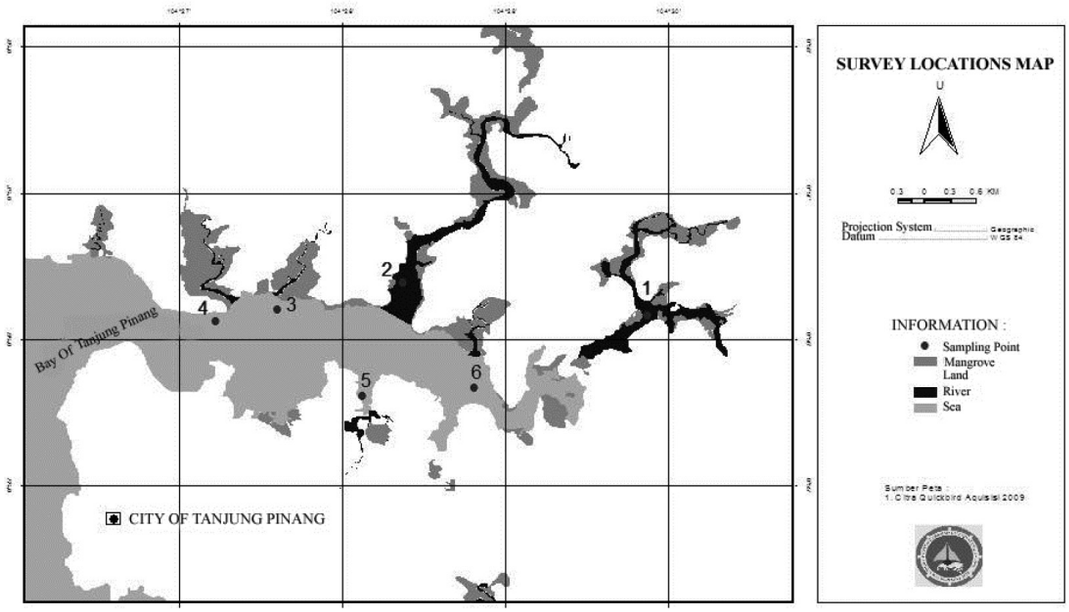

Figure 1: Location of study pollution load—analysis and assimilation capacity—Tanjungpinang Gulf waters.

$$TBP = \sum_{i=1}^{n} BP$$

where TBP = Total pollution load, n = number of rivers and i = load pollution of the river to i.

To convert to the pollution load in tonnes/year, multiply by $10^{-6} \times 3600 \times 24 \times 360$.

Assimilation capacity analysis is done by making a chart of the concentration for each pollution parameter in the waters from the bay area with the parameter "total pollution load" in the river mouth. Then analyzed by means, keep back the value line of sea water quality standards intended for sea biota based on the Ministry of Environment No. 51 of 2004.

Results and Discussion

Pollution Load on Tanjungpinang Bay Area

Based on the results of the analysis, it can be seen that the pollution load in the waters of the Tanjungpinang bay area measured on several parameters indicators of water pollution consists of: Total Suspension Solid (TSS), Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Nitrate (NO_3), Nitrite (NO_2), ammonium (NH_4), and Ortho-Phosphate (PO_4-P). Furthermore, the observation of organic waste pollution load for each of the parameters that go into the waters of Tanjungpinang Bay area can be seen in Table 1.

Table 1 shows the highest pollution load coming into Gulf waters Tanjungpinang for TSS parameters found on the Cape station amounted to 124.711 tons/year, and the second highest was found in the waters of Tanjung Unggat station in the amount of 107.495 tons/year. The next highest TSS load comes from the waters of the Carang, Sungai Ladi and the waters of Kampung Bulang respectively as 58.787 tons/year, 44.417 tons/year and 38.631 tons/year. The lowest TSS load populous on the Sungai Ular station only amounted to 23.328 tons/year. The high pollution load of TSS found in the Tanjung Lanjut's waters caused by a lot of bauxite mining activity all around this area and also the mangrove forests logging activities around the river, so that when it rains the soil erosion-borne surface run-off enters the water system.

BOD_5 pollution load at the highest level in Tanjung Unggat river station is amounting to 6,718 tons/year. Pollution load is the next ultimate Carang river waters and the waters of Tanjung Lanjut in the amount of 4,703 tons/year and 4,535 tons/year. In the waters of the Ladi river and Bulangladi village, it was found to be 3,135 tons/year and 1,145 tons/year respectively. While the lowest BOD_5 pollution load was found in the Ular river station (622 tons/year). The high load of BOD_5 contaminants in waters of Tanjung Unggat caused the amount of domestic waste input that goes into the water.

The highest pollution load COD compounds found in Sungai Carang station in the amount of 335.867 tons/year and the second highest and the lowest at Sungai Ladi station (37.362 tons/year).

Pollution load nitrate (NO_3) and nitrite (NO_2) is the highest found in the Carang river station respectively of 921 tons/year and 404 tons/year, while the pollution load on Nitrate was the lowest at Bulang village station (24 tons/year) and the lowest nitrite was on the Ular river station for only 30 tons/year.

Table 1: The burden of pollution that goes into Gulf waters of Tanjungpinang

No.	*Pollutant sources*	*Pollution load (ton/tahun)*						
		TSS	*BOD_5*	*COD*	*NO_3*	*NO_2*	*NH_4*	*PO_4-P*
1	Carang river	58,787	4,703	335,867	921	404	878	114
2	Ular river	23,328	622	66,640	27	30	16	34
3	Ladi river	44,417	3,135	37,362	30	77	50	119
4	Tg. Lanjut river	124,711	4,535	215,789	79	231	151	166
5	Tg.Unggat river	107,495	6,718	96,074	74	50	7	118
6	Kp.Bulang river	38,631	1,145	39,347	24	33	13	56

The highest nitrate (NO_3-N) pollution load was in the Carang river waters which amounts 1,053 tons/year, and the next highest is found in Tanjung Lanjut river that amounting to 106 tons/year. While waters of the rivers at Tanjung Unggat river and Ladi river had a load of nitrate respectively by 49 tons/year and 30 tons/year. The high load level of nitrate in the waters due to the high input on Carang river as the domestic pollutants come from the community of urban activity from onshore fields, based on the result explained that the pollution load caused by the domestic waste consists of carbohydrates, fats and proteins generally. The decomposition of fat and protein nutrients will produce nitrate and ammonia, then the ammonia in the water will react to produce the ammonium.

The pollution load of ammonium (NH_4), the highest level was found in the Carang river station (878 tons/year), and the lowest was found in Tanjung Unggat station (7 tons/year). The high load of ammonium in the Carang river waters was due to the high decomposition process of organic matter in the water column hypothetically as mentioned by Pasche (1988). In the shallow waters nitrogen is described into ammonium by the microbial benthic and animal communities that can provide a larger or all N consumed in the water column. Furthermore, Sorensen (1988) described that the concentration of ammonium is rare to 1 mg/l at the top of the mixed layer or the open waters of the deep ocean, but instead found a greater value than the level in the estuary and bay area which are polluted.

Pollution load of orthophosphate (PO_4-P), the highest level found in the Tanjung Lanjut river station was 166 tons/year, and the lowest level was found in the Sungai Ular station which only amounted to 34 tons/year.

Assimilation Capacity of the Water of Tanjungpinang Bay

In this study, assimilation capacity is aimed to determine how much the waters on Tanjungpinang bay are capable of receiving the pollution load by organic pollutants, so it does not degrade the ecological functions of the waters. The analysis to the assimilation capacity on Tanjungpinang Bay are based on the correlation between the concentration of organic waste in the waters of the bay and also the pollution load in the estuaries. Then the results of the calculation of the pollution load and each parameter concentration compared to the value of sea water standard quality which is applied to the marine life by The Minister of Environment Decree No. 51/MENLH/2004. This activity to determine the characteristics of the water environment at the present, is associated with an increase in the number of inputs from organic pollutants to the aquatic environment. Furthermore, the capacity of assimilation measured by the regression analysis between the concentration of nitrogen on waters of Tanjungpinang Bay with a load of organic pollutants in the estuary are shown in Figure 2.

The assimilation capacity values and the correlations function between the concentration of the parameters by organic pollutants in the waters of Tajungpinang Bay area with a load of organic pollutants which comes from the estuary that empties into the Tajungpinang Bay could be seen in Table 2.

The assimilation capacity for TSS is done by using a regression equation $Y = 0.0001\ X + 11.304$ with a coefficient of determination ($R^2 = 0.6671$) means that 66.71% of the variation in the coastal TSS concentrations described by TSS load in the estuary. TSS assimilation capacity in the waters amounted to

Table 2: The results of assimilation capacity analysis in waters of Tanjungpinang Bay

Parameter	*Y Function*	R^2	*Waste load (tons/year)*	*Assimilation capacity (tons/year)*
TSS	Y = 0,0001 X + 11,304	0.6671	397.369	686.960
BOD_5	Y = 0,0003 X + 0,1185	0.8555	20.858	67.062
COD	Y = 0,0001 X + 15,907	0.6446	791.079	640.930
Nitrate	Y = 0,0001 X + 0,0169	0.9456	1.156	-89
Nitrite	Y = 0,0006 X + 0,0657	0.6259	824	-9
Ammonium	Y = 0,0002 X + 0,0714	0.5720	1.115	1.143
Phosphate	Y = 0,0004 X + 0,0199	0.5359	606	-12

686.960 tons/year, while the TSS pollution load coming into the waters amounted to 397.369 tons/year.

The assimilation capacity for BOD_5 determined using a regression equation $Y = 0.0003\ X - 0.1185$, with a coefficient of determination ($R^2 = 0.8555$) means that 85.55% of the variation in concentrations of BOD_5 by the coast describedload BOD_5 in the estuary. The results of the regression line of intersection with the line of quality raw produce assimilation capacity BOD_5 value in the waters of Tanjungpinang bay are 67.062 tons/year, while the load BOD_5 entering into the waters of 20.858 tons/year.

The assimilation capacity for COD determined using a regression equation $Y = 0.0001\ X + 15.907$, with a coefficient of determination ($R^2 = 0.6446$) means that 64.46% of the variation in the coastal COD concentration is described by the COD load in the estuary. The results of the regression line of intersection with the line of quality raw produce assimilation capacity COD value in the waters of Tanjungpinang bay are 640.930 tons/year, while the COD load of waste that goes into the waters amounted to 791.079 tons/year. Thus, the COD pollutions load coming into the Tanjungpinag bay already exceeded the capacity of assimilation of these waters.

The assimilation capacity for nitrate (NO_3) is determined using a regression equation $Y = 0.0001\ X + 0.0169$, with a coefficient of determination ($R^2 = 0.9456$) means that 94.56% of the variation of nitrate concentration in coastal described by the nitrate load in estuary. The result of the intersection of the regression line with the quality standard lines generate value assimilation capacity about –89 tons/year, while the nitrate load comes into the water which amounts 1,156 tons/year. Negative values for nitrate assimilation capacity means the need for pollutant load reduction of 89 tons/year at the time of observation, assuming at the same time the pollution load must be equal to zero; thus the quality of the water will be in accordance with applicable standards. In Figure 2 shows that the waters of the Tanjungpinang bay no longer are able to assimilate the nitrate load coming from the river so the pollutants that enter will be higher. This is presumably because the amount of nitrate pollutants that contamines the water comes from anthropogenic that can't be neutralized by the hydrodynamics activity of these waters.

The assimilation capacity of nitrite (NO_2) based on the intersection results, which explain that regression line by quality standards is known for nitrite assimilation capacity value of –9 tons/year, while the load of nitrite pollutants into the waters amounted to 824 tons/year. The nitrite state in the waters ofTanjungpinang bay as well as nitrate whose typically assimilation capacity was exceeded. The nitrite load contribution to the concentration of nitrite in the coastal waters from Carang river is in the amount of 404 tons/year, while the smallest came from the Ular river which is about 30 tons/year. Then the assimilation capacity of nitrite is determined using a regression equation $Y = 0.0006\ X + 0.0657$, with a coefficient of determination ($R^2 = 0.6259$) amounted to 62.59% means the sample variation in the coastal nitrite concentration can be explained by the burden of nitrite in the estuary. Figure 2 shows that the condition of waters on Tanjungpinang bay has exceeded capacity by nitrite parameter because the value of its assimilation capacity has been exceeded.

Determining the assimilation capacity of ammonium (NH_4) was performed using the regression equation $Y = 0.0002\ X + 0.0714$ with a coefficient of determination ($R^2 = 0.572$) means that 57.2% of the variation of ammonium concentration in coastal is described by ammonium load in the estuary. Ammonium assimilation capacity measured to 1,143 tons/year, while the load of ammonium that goes into these waters was about 1,115 tons/year. It is seen that the condition of the waters on Tanjungpinang bay have exceeded the carrying capacity of the waters as a result of ammonium inputs from estuaries around these bay area, although in some estuaries (e.g. in the Ular river estuaries and Sungai Ladi) the ammonium contribution burden is still lower than the value of the assimilation capacity, as in creeks the river ammonium content is still high enough that would impede the process of the formation of nitrate to ammonium.

The assimilation capacity of phosphate done using regression equation $Y = 0.0004\ X + 0.0199$ with a coefficient of determination ($R^2 = 0.5359$) means that only 53.59% of the variation in the concentration phosphate on Tanjungpinang bay described by phosphate in estuaries. Phosphate assimilation capacity was –12 tons/year, while the load phosphate pollutant that goes into these waters is in the amount of 606 tons/year. The negative value of the phosphate compounds assimilation capacity means that the need for pollutant load reduction of 12 tons/year at the time of observation, assuming at the same time the pollution load must be equal to zero; thus the quality of the water will be contaminated in accordance with the applicable standards. Figure 2 shows that the waters of Tanjungpinang bay is no longer able to assimilate the incoming phosphate load of the river so that the pollutants that enter will be higher. This

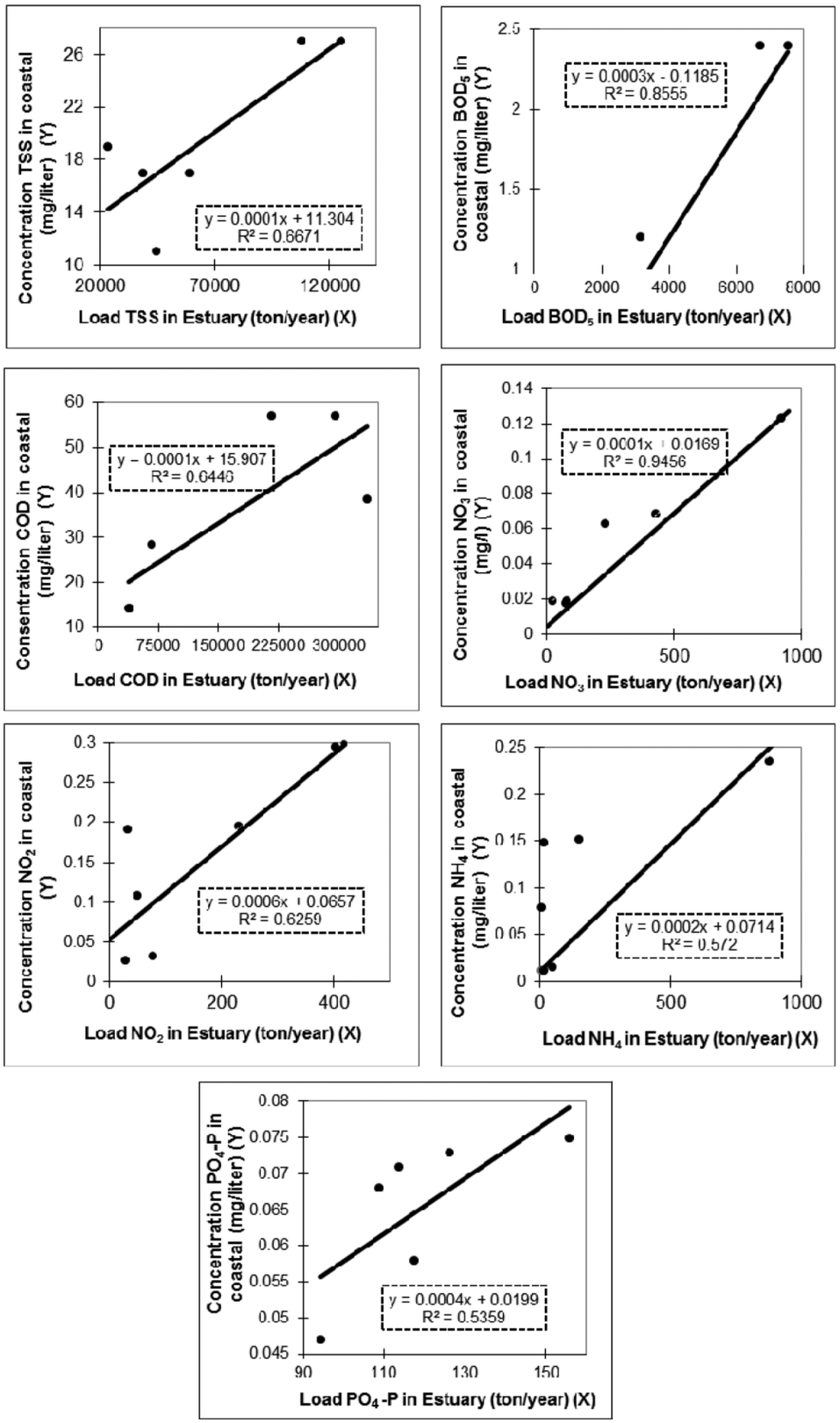

Figure 2: The relationship between the concentration of pollutants and pollution load.

is presumably because the amount of pollutants that go into the waters, phosphate derived from anthropogenic pollutant that can't be neutralized by the hydrodynamic activity in the waters of Tanjungpinang bay.

Conclusion

Based on the results of pollution load of organic and its assimilation capacity in waters of Tanjungpinang bay can be concluded as follows:

1. The pollution load found in the waters of Tanjungpinang bay for each parameter is TSS amounted to 397.369 tons/year, BOD_5 amounted to 20.858 tons/year, COD amounted to 791.079 tons/year, nitrate of 1,156 tons/year, nitrite 824 tons/year, the ammonium amounted to 1,115 tons/year and ortho-phosphate amounted to 606 tons/year.
2. The assimilation capacity in the waters of Tanjungpinang bay for each parameter is TSS amounted to 689.960 tons/year, BOD_5 amounted to 67.062 tons/year, COD amounted to 640.930 tons/year, nitrates should be reduced by –89 tons/year, nitrite –9 tons/year, ammonium amounted to 1,143 tons/year and ortho-phosphate should be reduced by –12 tons/year.

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