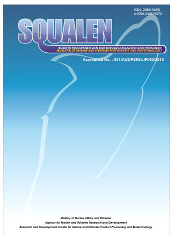

Squalen Bull. of Mar. and Fish. Postharvest and Biotech. 12 (2) 2017, 67-74

www.bbp4b.litbang.kkp.go.id/squalen-bulletin

Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology

ISSN: 2089-5690
e-ISSN: 2406-9272

COMPARISON OF STORET AND POLLUTION INDEX METHOD TO ASSESS THE ENVIRONMENTAL POLLUTION STATUS: A CASE STUDY FROM LAMPUNG BAY, INDONESIA

Giri Rohmad Barokah, Farida Ariyani, and Tuti Hartati Siregar

Research Center for Marine and Fisheries Product Processing and Biotechnology,
Jalan K.S. Tubun Petamburan VI, Jakarta, 10260, Indonesia

Article history:
Received: 6 May 2017; Revised: 24Juli 2017; Accepted: 31 Juli 2017

Abstract

The determination of pollution status is an important process of environmental quality monitoring especially in strategic waters for coastal areas, such as in Lampung Bay. An effective and sensitive Water Quality Index (WQI) method is needed, to accurately determine the environmental pollution status. This study aimed to compare the sensitivity of Storage and Retrieval of Water Quality data System (STORET) and Pollution Index (PI) as a WQI method, a case study from Lampung Bay coastal waters, Indonesia. Water quality analysis i.e. Dissolve Oxygen (DO), pH, salinity, nitrite, nitrate, phosphate and ammonia was conducted spatially (three zones of Lampung Bay; river mouth, aquaculture and bay area) and seasonally (April and October 2015). The study found that nitrate and phosphate values were exceeded the limits of water quality standard (Indonesia Ministry of Environment Decree No. 51/2004) for marine organisms. However it may still support the aquaculture activities. The two WQI methods produced different pollution status of Lampung bay. STORET was found to be more sensitive method. Pollution Index method revealed a status of moderately polluted while STORET showed heavily polluted status. Therefore, this study suggest the use of STORET index, compare to Pollution Index, in an assessment of pollution status at watershed area.

Keywords: pollution index, STORET index, water quality, Lampung Bay

1. Introduction

Ocean is an area with wealth of natural resources which is very important for human life and other living organism. That is why the utilization of marine space is growing rapidly by the day. However, in addition to positive impact of providing economic benefits, the utilization of the marine space also causes some negative impacts. According to Cicinsain and Knecht (1998), utilization of inclusively and rapidly grown marine spaces in exceeding the carrying and sustainable capacity of the marine ecosystems is potential to degrade the marine water quality that lead to marine pollution and alter the equilibrium of ecosystems within it. Mukhtasor (2007) stated that the source of marine pollution includes threats from terrestrial sources, oil spills, untreated waste, waters enforcement, enrichment of nutrients, invasive species, persistent organic contamination (POPs), heavy metals, water acidification, radioactive compounds, waste, overfishing and the destruction of coastal habitats.

Determination of pollution status is one of the first steps in the process of monitoring and preventing water quality degradation (Suwari, Riani, Pramudya & Djuwita, 2010). Water quality variables can be used to determine pollution status include temperature, color, pH, brightness, turbidity, TSS, DO, BOD, COD, phosphate, NO_3, NO_2, NH_3, bacteria, cyanide and heavy metals (Darmayati, Djoko, & Ruyitno, 2009; Liu et al., 2011; Polii, Bobi & Desmi, 2002; Rochyatun, Lestari & Rozak, 2005; Siahaan, Indrawan, Soedarma, & Prasetyo, 2011; and Soekadi, 1999). Decree of the Indonesian Minister of Environment No. 115/2003 suggests two different Water Quality Index (WQI) methods to assess water pollution level, namely *Storage and Retrieval of Water Quality Data System* (STORET) and Pollution Index (PI). However, these methods use different level of data; Pollution Index

*Corresponding author.
E-mail:girirohmadbarokah@gmail.com

DOI: http://dx.doi.org/10.15578/squalen.v12i2.287.

may use one water quality observation data, while STORET Index must use time series data consisting of at least two water quality observation data (Setyobudiandi et al., 2009). Those differences may result into a different level of method sensitivity.

Among scientists the use of water quality index to classify the quality of water still considered controversial because one index considered not able to describe overall existing water quality conditions. Moreover, many water quality parameters are not covered in the index (Saraswati, Sunyoto, Kironoto, & Hadisusanto, 2014). For that reason, an effective and sensitive Water Quality Index (WQI) method is needed to accurately determine the environmental pollution status. Therefore, this study aimed to compare the sensitivity of Storage and Retrieval of Water Quality Data System (STORET) and Pollutant Index as a WQI method. The study was conducted at Lampung Bay coastal waters. Lampung Bay provides an area for several activities including capture fisheries, aquaculture port, tourism and also military (Yulianto, 2013). However, these various activities may generate water quality degradation of Lampung Bay. The condition was proved by the frequent occurrence of fish mass death in *floating net cage* of Lampung Bay. Therefore it is necessary to assess Lampung Bay water pollution status using different WQI methods approach. The result of this study is expected to be used as information for local environmental management authorities who assessing the coastal pollution status.

2. Material and Methods

2.1. Location of the Study

The study was conducted in April (east monsoon) and October (west monsoon) 2015 in Lampung Bay waters with latitude coordinate range 5º26'0''LS – 5º42'0''LS and longitude coordinate range 105º10'30''BT - 105º30'30''BT. The sampling locations were 58 points. The coordinates of each location point were recorded with GPS (Garmin 585) and then plotted to the map (Ina Geoportal, 2017) using ArcGIS Desktop 10.2 software. Sea water samples were taken by purposive random sampling stations which represent river mouth area, floating net cage aquaculture and bay area.

2.2. Sample Collection and Analysis Procedures

One liter of marine water samples were taken at 1 m depth from each study point using water sampler (Nansen) (Hutagalung, Setiapermana & Riyono, 1997). The marine water samples preservation procedure refers to APHA (2005). Marine water samples were placed in a 1 L polyethylene (PE) bottle and stored at 4 ºC in a cool box. The pH, temperature, salinity and DO were measured in situ using portable tools analysis pH-meter (Hanna HI 98107), DO-meter (HACH HQ40D) and refractometer (Atago), while nutrient analysis (ammonia, phosphate, nitrite and nitrate) were conducted in the laboratory using Colorimeter HACH DR-890.

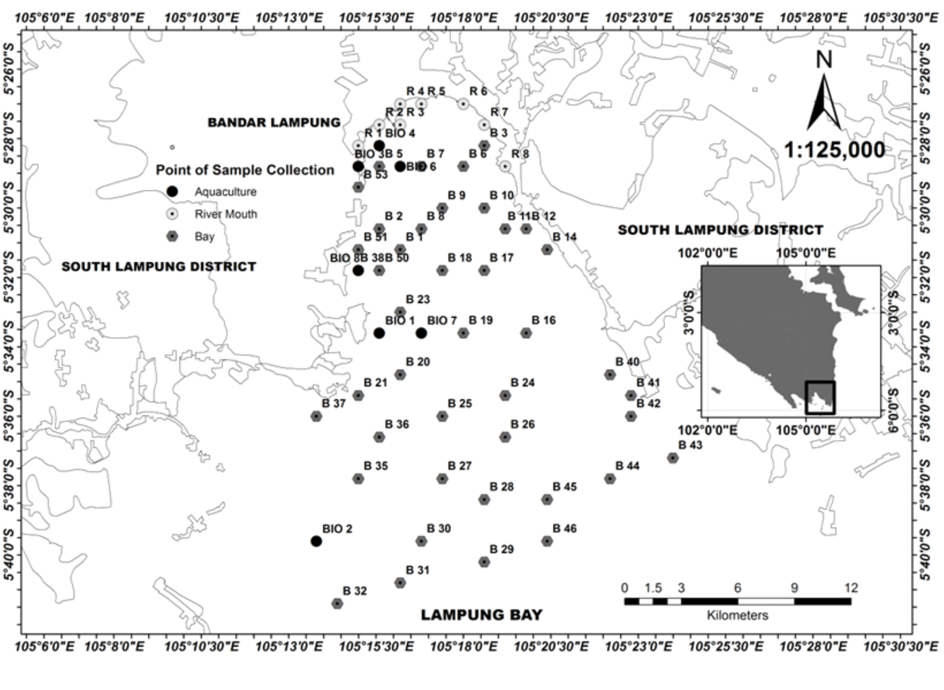

Figure 1. Research location and station.

2.3. Data Analysis

Spatial – temporal characteristics were analyzed using multivariate test *Multidimensional scaling* / MDS (seasonal data; west monsoon and east monsoon) and *Discriminant Analysis* / DA (spatial data; river mouth, aquaculture and bay). Before multivariate analysis was performed, the environmental data was transformed using log function and tested for normality using Shaphiro-Wilk W (Loayza-Muro et al., 2010). The Lampung Bay water quality was then analyzed by comparing the data to the Water Quality Standard of Ministry of Environment Decree 51 of 2004 for protection of marine aquatic life.

Analysis of water quality status using pollution index was based on Hammer & Harper (2006), as shown in equation (1), which determine the level of pollution relatively to certain water quality parameters (Suwari et al., 2010). The score and status of pollution index is shown in Table 1. Furthermore, analysis of water quality status in the Lampung Bay based on STORET index method was conducted by procedure that described in the Ministry of Environment Decree 115 of 2003. This index consists of three categories of water quality parameters (physics, chemistry, and biology) that will be summed. The assessment of each parameter was distinguished by the number of samples that was below, equal to, or above 10 times of the fetch. Each of the parameter measured was averaged. In addition to that, the maximum and the minimum figures were also acquired. All the three values were then compared with the quality standard value and then were scored. Scoring refers to a rating system developed by the Canter (1977) on the assessment of the status of water quality as in Table 2 and was interpreted based on the criteria as in Table 3.

$$IP = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)_m^2 + \left(\frac{Ci}{Lij}\right)_r^2}{2}}$$

Note :

IP : Pollution Index

Ci : Concentrations of water quality parameters

(i) : (units adapted to Water quality parameters which was observed)

Lij : Standard of water quality parameters (i) designation of water (j) (unit adjusted for water quality paramaters which was observed)

$(Ci/Lij)_m$: Maximum value Ci/Lij

$(Ci/Lij)_r$: Average value Ci/Lij

Table 1. Pollution score and status of pollution index based on Ministry of Environment Decree No.115/2003

Value	Water Pollution Status
0 ≤ IP ≤ 1.0	Good condition
1.0 ≤ IP ≤ 5.0	Lightly polluted
5.0 < IP ≤ 10	Moderately polluted
IP ≥ 10	Heavily polluted

Table 2. Scoring determination of water quality status by STORET Index (Canter, 1977)

Number of sample	Score	Parameters		
		Physics	Chemistry	Biology
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
> 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	18

Table 3. Pollution score and status with STORET Index based on scoring system by US-EPA

Class	Criteria	Score	Quality Status
A	Very good condition	0	Good condition
B	Good condition	(-1) – (-10)	Lightly polluted
C	Moderately good condition	(-11) – (-30)	Moderately polluted
D	Bad condition	≥ -31	Heavily polluted

3. Results and Discussion

3.1. Spatial and Seasonal Characteristics of Lampung Bay Water Quality

Spatial and seasonal characteristics of Lampung Bay sea water quality were detected as insignificantly different (P<0.05) (Figure 2). Seasonal analysis (Figure 2a.) showed that the dispersion of stations in the west monsoon was wider than in the east monsoon, which may be related to geographical location. The Sunda Strait received a stronger current during west monsoon than during east monsoon season. Moreover, climatological conditions may also influence the amount of pollutant input (Supangat, 2008). Transitional monsoon in April may happen by lower wind speed and higher rainfall, while west monsoon in October was characterized by the high wind speed and low rainfall (Kurniawan, Habibie & Suratno, 2011). Liu et al. (2011) also showed that the distribution of pollution substances at the Bohai Sea, China was wider in rainy season. Meanwhile, the main factor (88%) that separated the characteristic of water quality in the Lampung Bay zones was related with salinity and oxygen levels (Figure 2b). The bay zone had higher oxygen and salinity level, compared to the river mouth and aquaculture zones. Moreover, ammonia nutrient appeared as the characteristic of river mouth waters. The horizontal distribution of nutrients in the river and the river mouth were high because of the waste run-off from terrestrial anthropogenic activities (Hutagalung & Rozak, 1997; Mezuan, 2007; Mukhtasor, 2007; Shanmugam, Neelamani, Ahn, Philip, & Hong, 2006).

Temperature, pH, and salinity level (Table 4) were detected as normal for coastal region and optimum for tropical fish (Akbar & Sudaryanto, 2001;Kordi & Tancung, 2005; Yulianto, 2013). Moreover, the DO level (> 4 mg / L) of the Lampung Bay was still able to support the fisheries activities especially to support the floating net cage aquaculture (Tatangindatu, Kalesaran & Rompas, 2013). The DO level was lower in the river mouth zone, in particular at station R3 that was below the standard level (3.5 mg/L). Patty (2013) found that the average DO levels at the river mouth (estuary) in Kema Waters, North Sulawesi was <5,34 mg/L and at near the coast was <3,86 mg/L. Moreover, Patty (2013) stated that generally the lowest DO levels in the study was found in the station near the river mouth while the highest DO level was found in the station that far form the coast. Alledgely, It was due to the activity of aerobic microorganisms that decomposed organic substances which then caused physiological disorders for marine biota, especially in the process of respiration

Meanwhile, the nutrient level may be classified as exceeding the water quality standard for marine biota established by Ministry of Environment Decree number 51 year of 2004 (Table 5). Eutrophication was detected especially in the river mouth zone. High level of inorganic nitrogen was found even for nitrite which generally was found in small amounts due to the presence of dissolved oxygen (Payne, Brown, Reusser, & Lee, 2012). Inorganic nitrogen content commonly correlates with contamination of organic matter and low DO level which may disrupt the physiological of aquatic organism (Zulfa, Effendi, & Riani, 2016).

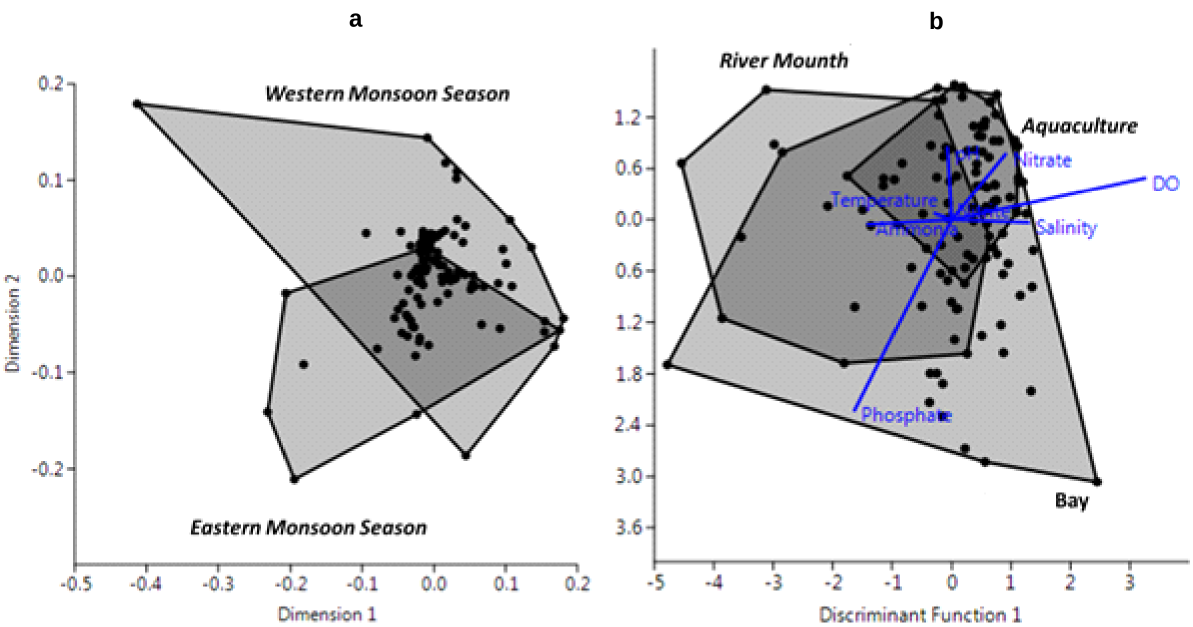

Figure 2. Assessment of water quality analysis using Multidimensional Scalling paramaters by seasonally (a) and Discriminant Analysis by spatially (b) from Lampung Bay.

Table 4. Characteristics of temperature, pH, DO and salinity at Lampung Bay in April and October based on the water quality standard for marine biota

Monsoon	Zones	Temperature (^oC)	pH	DO (mg/L)	Salinity (ppt)
East (April)	Bay	30.03 ± 0.41	8.26 ± 0.07	7.86 ± 0.58	34.12 ± 1.07
	Aquaculture	30.30 ± 0.26	8.25 ± 0.06	8.15 ± 0.29	33.57 ± 1.27
	River Mouth	30.53 ± 0.66	8.04 ± 0.23	6.56 ± 1.16	30.50 ± 3.12
West (Oktober)	Bay	29.53 ± 0.41	7.91 ± 0.34	7.71 ± 0.24	32.78 ± 1.29
	Aquaculture	29.74 ± 0.57	7.88 ± 0.18	6.84 ± 1.14	33.09 ± 1.63
	River Mouth	30.44 ± 0.39	6.40 ± 0.88	7.39 ± 1.60	32.88 ± 1.36
Standard value*		normal	7.0 – 8.5	> 5	normal

Note: *Ministry of Environment Decree number 51 year of 2004

Table 5. Characteristics of nutrient at Lampung Bay in April and October based on the water quality standard for marine biota

Monsoon	Zones	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia (mg/L)	Phosphate (mg/L)
East (April)	Bay	0.008 ± 0.007	0.59 ± 0.10	0.00 ± 0.00	0.13 ± 0.11
	Aquaculture	0.011 ± 0.008	0.50 ± 0.35	0.00 ± 0.00	0.03 ± 0.02
	River Mouth	0.015 ± 0.019	0.63 ± 0.07	0.13 ± 0.15	0.26 ± 0.07
West (Oktober)	Bay	0.014 ± 0.006	0.61 ± 0.19	0.01 ± 0.04	0.05 ± 0.05
	Aquaculture	0.012 ± 0.009	0.55 ± 0.30	0.02 ± 0.05	0.07 ± 0.04
	River Mouth	0.014 ± 0.12	0.54 ± 0.25	0.05 ± 0.14	0.06 ± 0.07
Standard value*		-	0.008	0.3	0.015

Note: *Ministry of Environment Decree number 51 year of 2004

Furthermore, high level of phosphate was also detected. The level can be characterized as highly fertile waters environment according to EPA (2002). High level of phosphate may happen because the diffusion of phosphate from aquatic sediments and from the flow and turbulence of the water mass which resulted in the elevation of the high phosphate content of the bottom of the surface layer (Patty, 2013; Paytan & McLaughlin, 2007). Moreover, the nitrogen eutrophication pressure may be derived from domestic waste runoff, agriculture or from the aquaculture area. In general, the analysis of the nutrient parameters indicates that the content of eutrophication has potential to cause algal population explosion that can harm the biodiversity of aquatic ecosystems (Risamasu & Prayitno, 2011).

3.2. Water Quality Analysis of Lampung Bay Based on STORET Index and Pollutant Index

Water quality of Lampung Bay based on Pollutant Index was presented in Figure 3. The analysis shows that the water of Lampung Bay (sampling points of river mouth, bay and aquaculture zone) on average were moderately polluted, both at April and September. STORET Index measurement was conducted to know the water quality of each study point location so that it will give more comprehensive description about the Lampung Bay water quality. The study result based on STORET index found that the Lampung Bay waters either in April (east monsoon) or in October (west monsoon) were heavily polluted. That result was different from the pollution index-based calculation result which stated that the study sampling station in river mouth, bay and aquaculture zone of Lampung Bay were moderately polluted in both seasons.

The results indicated that the pollution levels determined based on the Pollution Index and STORET Index was different. The difference level of pollution was expected as quality status rating system and water pollution in both methods. The ordinal number is an assessment used in the STORET Index whereas the ratio was an assessment of the Pollution Index. According to Suwari et al. (2010), calculation of water pollution status by Pollution Index method has big

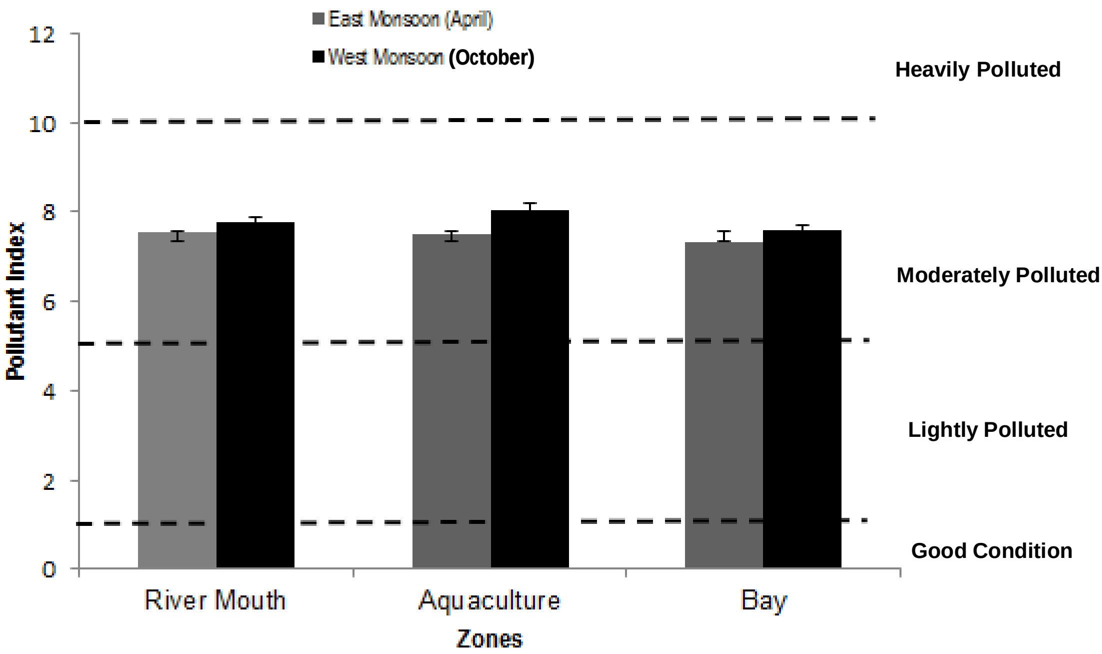

Figure 3. The contamination status of Lampung Bay based on the pollution index value.

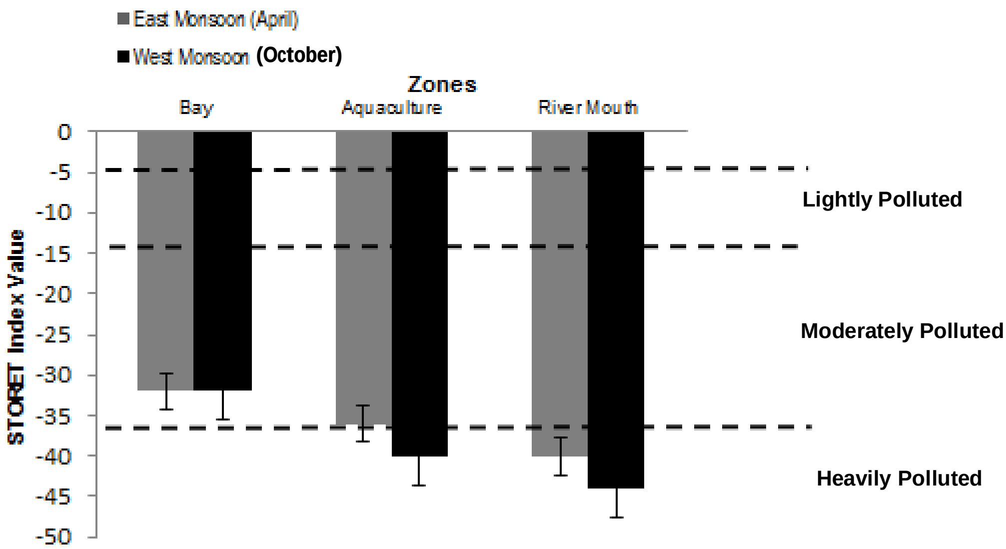

Figure 4. The contamination status of Lampung Bay based on STORET index value.

enough tolerance or less sensitive toward the difference of the pollution parameter value. In addition, the calculation of Pollution Index method is only influenced by one of the water quality parameters which has the parameters maximum ratio to the waters quality standard compared to the ratio of the average water quality parameters that exceed the quality standard (Kannel, Lee, Lee, Kanel & Khan, 2007).

The STORET method is better than the Pollution Index method in terms of sensitivity. The STORET method is more stable than the Pollution Index method to detect the dinamycs of water quality at each location (Suwari et al., 2014). Moreover, Pollutant Index method is less sensitive to differentiate the class of water quality status due to its big tollerance if more than one parameters exceed the water qualilty standard. This is matter because in the Pollutant Index method, what considered as important determinant in the PI score is a parameter which has a maximum (Ci / Lij) compared to the average of all water quality parameters measured (Saraswati et al., 2014). Therefore, this study showed that the STORET index would be better to be used in the assessment of watershed area pollution status.

4. Conclusion

The pollution status of Lampung Bay based on Pollution Index method analysis was moderately polluted while based on STORET Index analysis was heavily polluted. Therefore it is recommended to use the STORET analysis for assessment of pollution status in a watershed due to the sensitivity of the method analysis. By applying the STORET index, Lampung Bay was classified as heavily polluted waters, which may have an impact on human health and on economy sector.

References

Akbar, S. & Sudaryanto. (2001). *Germination and Enlargement of Duck Grouper*. Jakarta : Penebar Swadaya

APHA. (2005). *Standard Method for the Examination water and Wastewater* (15 th Edition) (pp.1134). Washington. D.C : American Public Health Association.

Canter, L.W. (1977). *Environmental Impact Assesment, University of Oklahoma* (pp. 86 – 118). New York : McGraw-Hill Book Company.

Cicinsain, B & Knecht, R. W. (1998). *Integrated Coastal and Ocean Management : Concepts and Practices*. Washington D.C : Island Press.

Environmental Protection Agency (EPA). (2002). *Water Quality Criteria. Mid-Atlantic Integrated Assessment (MAIA) Estuaries* (pp. 595). USA : Ecological Research Series Washington

Darmayati, Y., Djoko, H., & Ruyitno. (2009).*Dinamycs of Bacterial pollution indicator in Cisadane estuary waters*. *Jurnal Oseanologi dan Limnologi Indonesia*, 35(2),273-290.

Hammer & Harper, D. A. T. (2006) *Paleontological data analysis* (pp. 351). Oxford : Blackwell Scientific Publication.

Hutagalung, H.P., Setiapermana, D., & Riyono. S.H. (1997). *Sea Water Analysis Method. Sediment and Biota* (Buku 2) (pp. 182). Jakarta, Lipi : Puslitbang Oseanologi

Hutagalung. H.P. & Rozak. (1997). *Sea Water Analysis Method. Sediment and Biota.* (Buku 2) (pp. 85-87). Jakarta, Lipi : P2O

Ina Geoportal. (2017). Indonesia Geospatial Portal (Geospatial Untuk Negeri). *https://www.tanahair.indonesia.go.id/portal*. retrieved at 2 August 2017

Kannel, P. R., Lee, S., Lee, Y. S. Kanel, S R., & Khan, S.P. (2007). Application of Water Quality Indexes and Dissolved Oxygen as Indicators for River Water Classification and Urban Impact Assessment. *Journal of Environmental Monitoring Assessment*, 13(2), 93-110.

Kordi, M. G. & Tancung, A. B. (2005). Water Quality Management (pp. 208). Jakarta : Penerbit Rineka Cipta.

Kurniawan, R., Habibie, M.N., & Suratno. (2011). Monthly Variation of Sea Waves in Indonesia. *Jurnal Meteorologi dan Geofisika,* 12(3),221-232.

Liu, S., Sha, L., Cuiping, K., Wenrui, H., Wujun, C., Jianle, Zg., and Guihui Z. (2011). Water quality assessment by pollution-index method in the coastal waters of Hebei Province in western Bohai Sea. China. *Marine Pollution Bull*, 62 (2), 2220–2229.

Loayza-Muro, R.A., Elías-Letts, R., Marticorena-Ruíz, J.K., Palomino, E.J., Duivenvoorden, J.F., Kraak, M.H.S., and Admiraal, W. (2010). Metal-induced shifts in benthic macroinvertebrate community composition in Andean high altitude streams. *Environ Toxicol Chem*, 29(12), 2761–2768

Ministry of Environment Republic Indonesia. (2003). Ministry of Environment Decree number 115 of 2003 About the Guidelines for Determination of Water Quality Status. Jakarta (ID).

Ministry of Environment Republic Indonesia. (2004). Ministry of Environment Decree number 51 of 2004 About Marine Water Quality Standard. Jakarta (ID).

Mukhtasor. (2007). *Coastal and Marine Pollution. Jakarta* (ID): Pradnaya Paramita.

Payne, M.C,. Brown, C.A, Reusser, D.A., Lee, H.II,. (2012). Ecoregional Analysis of Nearshore Sea-Surface Temperature in the North Pacific. *PLOS ONE,* 7(1), 98 -105.

Paytan, A.and McLaughlin, K .(2007).The Oceanic Phosphorus Cycle. *Chem. Rev*, 107 (2), 563-576.

Patty, S. I. (2013). Distribution of Salinity, Temperatures and Dissolved Oxygen in the Kema Waters. Sulawesi Utara. *Jurnal Ilmiah Platax*, 1 (3) , 148 – 157.

Risamasu, F.J.L. & Prayitno, H.B. (2011). Study of Phosphate, Nitrite, Nitrates and Silicates in the Waters of the Matasiri Islands. *Jurnal Ilmu Kelautan UNDIP*, 16 (3), 135-142.

Polii, N., Bobi, S. & Desmi, N. (2002). Estimation of mercury and cyanide content in Buyat Minahasa Watershed (DAS). *J Ekoton*, 2(1),31-37.

Rangka, N.A., and & Paena, M. (2012). Potential and Suitability of Seaweed Cultivation Area (*Kappaphycus alvarezii*) Around Waters of Wakatobi Regency, Southeast Sulawesi Province. *Jurnal Ilmiah Perikanan dan Kelautan*, 4(2), 151 -159.

Rochyatun, E., Lestari, & Rozak, A. (2005). The quality of the waters environment of Banten and its surroundings is viewed from the condition of heavy metals. *J Oseanologi dan Limnologi Indonesia*, 38, 23-46.

Saraswati, S. P., Sunyoto, Kironoto, B. A., & Hadisusanto. (2014). Assessment of the Forms and Sensitivity of the Index Formula PI, STORET, CCME for The Determination of Water Quality Status of A Tropical Stream in Indonesia. *J Manusia dan Lingkungan*, 21 (2), 129 – 142.

Setyobudiandi, I., Sulistiono, Yulianda, F., Kusmana, C., Hariyadi, S., Damar A., Sembiring, A., & Bahtiar. (2009). *Marine and fisheries applied data sampling and analysis method in coastal and marine area.* Bogor (ID): Makaira-FPIK

Supangat, A.B. (2008). The Influence of Various Land Use on River Water Quality in Pine Forest Area in Gombong. Kebumen. Central Java. *Jurnal Penelitian Hutan dan Konservasi Alam,* 5(3), 267-276.

Shanmugam, P., Neelamani, S., Ahn, Y.H., Philip, L., & Hong, G.H. (2006). Assessment of The Levels of Coastal Marine Pollution of Chennai City. Southern India. *Springer Science*, 2(1),12-20.

Suwari, Riani, E., Pramudya, B., & Djuwita, I. (2010). Determination of Water Quality Status of Surabaya River Water with STORET Method and Pollution Index. *Majalah Ilmiah Widya*, 27(2),59-63.

Soekadi. (1999). River pollution caused by waste disposal and its effect on BOD and DO [makalah]. Bandung (ID) : Institut Keguruan dan Ilmu Pendidikan

Siahaan, R., Indrawan, A., Soedharma, D., & Prasetyo, L.B. (2011). The water quality of the Cisadane River. West Java-Banten. *J Ilmiah Sains*, 11(2), 268-272.

Tatangindatu, F. O., Kalesaran & Rompas, R. (2013). Study of Water Chemical and Physics Parameters at Fish Cultivation Area in Lake Tondano . *Jurnal Budidaya Perairan*, 1 (2), 8-19.

Yulianto, H. (2013). Water Quality Spatial Distribution Mapping of Nutrient Elements in Lampung Bay Pemetaan. *Jurnal Ilmu Perikanan dan Sumberdaya Perairan AQUASAINS*, 2 (1), 113-117.

Zulfa, N., Effendi, H. & Riani, E. (2016). Preliminary Rapid Fishing Port Water Quality Assestment With Pollution Index. *International Journal of Bioflux Society*, 8 (1), 96 – 108.