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by Bambang Yulianto

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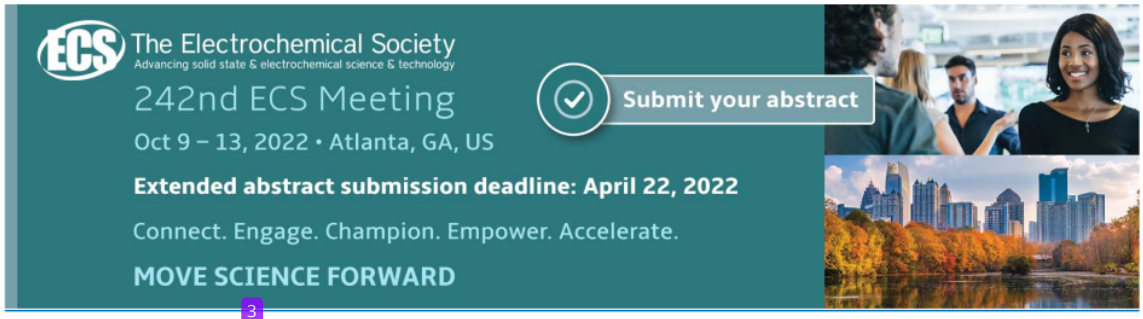

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Water Quality Assessment Based on National Sanitations Foundation Water Quality Index during Rainy Season in Sibelis and Kemiri Estuaries Tegal City

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Abstract. Sibelis and Kemiri are two important river estuaries in Tegal City, at the northern coast of Central Java. Both estuaries have differences in sources of pollution. Pollutants in Sibelis estuary come from industrial activities, such as the fillet household industry, fishing ports, and domestic pollution. While pollutants of Kemiri estuary come from pond fisheries, agricultural activities, and domestic pollutions. This study aims to assess the water quality of the Sibelis and Kemiri estuaries during the rainy season based on the Water Quality Index of the National Sanitation Foundation. The research was done on January–March 2019 (rainy season) with three sampling stations. Each station was divided into three sites. Eight water quality parameters were measured i.e. temperature, TDS, TSS, pH, BOD_5, DO, PO_4 and NO_3. The results showed that there was an increasing trend in the NSF WQI Index in Sibelis from January to March 2019 (48.02 to 51.25) and included in the poor quality category (49.61). Based on the Indonesian Ministry of Environment Standards (2004), six parameters were out of standard, namely TDS, TSS, BOD_5, DO, PO_4 and NO_3. While the results of Kemiri estuary show a decreasing trend from January to March 2019 (62.36 to 57.88) and fall into the medium quality category (62.08). Only four parameters have outside standards i.e. TDS, TSS, PO_4 and NO_3.

1. Introduction

Water quality is an indicator that reflects not only environmental health but also compliance with the living conditions of aquatic organisms. Even though the increase in several parameters of water quality, such as nutrients, has a positive effect on certain organisms [1] but generally biodiversity in an aquatic environment will decrease with deteriorating water quality. In extreme conditions, there will be mass mortality leading to the extinction of a certain organism due to decreased water quality and can not be tolerated by these organisms [2]. Significant changes in water quality will also reduce the genetic diversity of the environment, and to maintain its sustainability requires good management of water quality and the environment [3,4,5].

Ecosystem health is the target of various management efforts. The level of health of mangrove, coral, seagrass and estuarine ecosystems [6,7, 8,9] is strongly influenced by many factors including water quality [10]. An estuary is one of the habitats that often changes its water quality[11]

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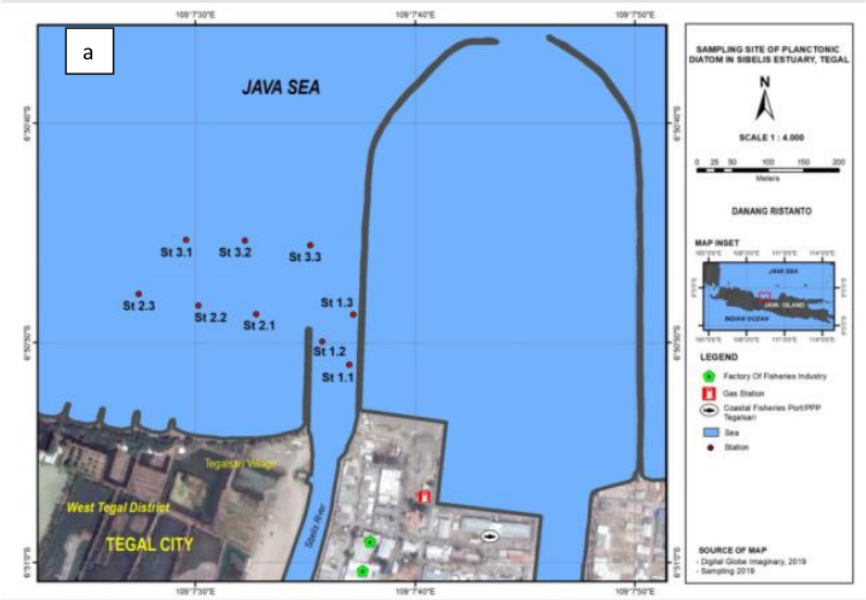
due to the influence of land and sea. Various sources of pollutants from land that are discharged into the river will flow into the estuarine and change the water quality [12]. Sibelis and Kemiri are two estuaries in Tegal City that have different sources of pollutants. Pollutants in Sibelis estuary originate from industrial activities, such as the fish fillet home industry, fishing port, and domestic pollution. While Kemiri estuary pollutants come from fish ponds, agricultural activities and also domestic pollution. [13].

National Sanitations Foundation Water Quality Index commonly called as NSF-WQI is standard tool assessment for water quality for all waters monitoring. It has a standard index to get conclusion about water quality. Understanding the parameters of water quality is important because it will encourage the implementation of appropriate policies for its management. The problems in an environmental assessment are generally caused by the measurement of parameters that are described into various values that confuse the public and decision-makers [14,15]. A examine the importance of the NSF-WQI where a water quality index is a tool for assessing the quality of an aquatic environment then reviewed the NSF-WQI that developed the parameters to become nine parameters [16,17,18,19,20] which also included in Indonesian regulation for assessing water quality [21]. This study aims to evaluate water quality at Sibelis and Kemiri estuaries by using NSF-WQI Index.

2. Materials and Methods

2.1. Sampling

Sampling was carried out for three months (January to March 2019) in both estuaries. Sibelis is a low mixed estuary, while Kemiri is a moderate mixed estuary because the mixing of rivers and seas is higher [22]. There were three stations and nine substations in each estuary (Figure 1). Station selection was based many consideration namely the transition location of rivers and coastal zones, therefore, the entire continuum of the river, estuary and coastal zones were obtained [22,23,24]. This can represent high mixing as station I, medium mixing (station II), and low mixing (station III).



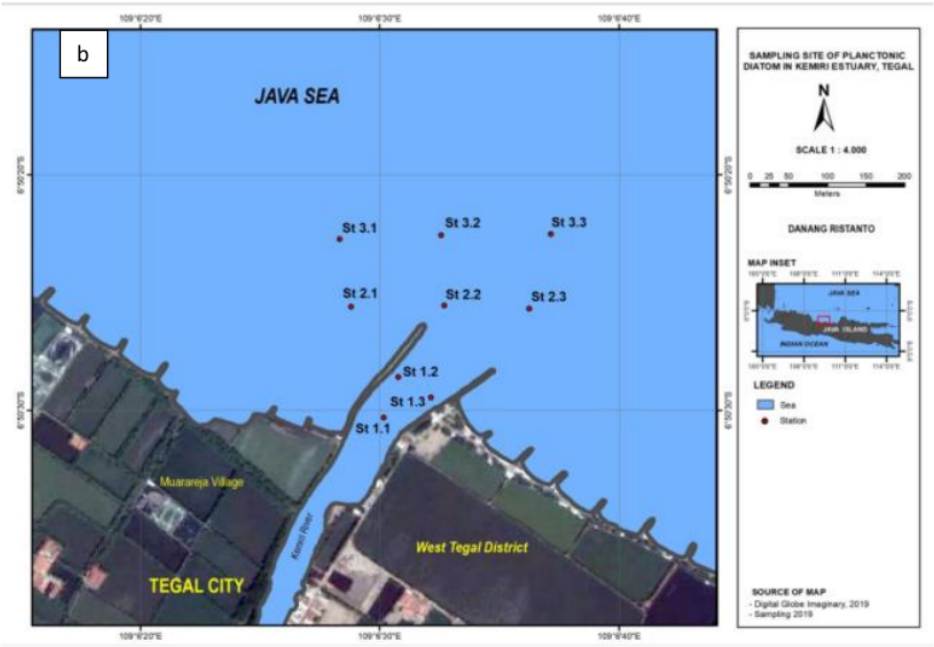


Figure 1. Sampling site of Sibelis (a) and Kemiri (b) Estuaries

2.2. *Water Quality Parameter*

Eight water quality parameters were measured i.e. dissolved oxygen (DO), pH, biological oxygen demand (BOD_5), nitrate, phosphate, total suspended solids (TSS), total dissolved solids (TDS) and temperature. These parameters were purposely chosen to assess water quality based on NSF-WQI.

2.3. *NSF-WQI Index Analysis*

The water quality was assessed using developed standard index for water quality assessment. Each individual water quality parameter was transformed into a unitless subindex (Qi) value using Q value [18,19,20]. The subindex for each parameter was multiplied by its weight (Wi) as shown in Table 1. The mathematical expression used to calculate the overall WQI is given by the equation below,

$$\mathbf{WQI} = \sum \mathbf{Wi.Qi}$$

WQI : Water quality index
W : Weight
Q : Quality of each parameters

The water quality index was divided into five categories (Ott, 1978) i.e. very bad (0-25), bad (26-50), middle (51-70), good (71-90), and very good (91-100) categories. Since data of fecal coliform were not obtained the weight of this missing parameter was distributed to other parameters based on the weight of each parameter in the index.

Table 1. Weights of water quality parameters

No	Parameters	Weight
1	DO	0,19
2	pH	0,13
3	BOD_5	0,13
4	NO_3	0,12
5	PO4	0,12
6	Suhu	0,12
7	TDS	0,10
8	TSS	0,09

3. Results

3.1. Parameter Out of Standard of Sibelis and Kemiri

The results showed that several water quality parameters in both estuaries had exceeded the quality standards set by the Decree of State Minister Environment Number 51 of 2004. There were six parameters of water quality in Sibelis that exceed the threshold, namely DO, BOD, Nitrate, Phosphate, TDS and TSS. See Figure 2 and 3. The value of those parameters were DO at 0,83-1,87 mgL^{-1} (standard 5 mgL^{-1}), BOD 34,31-37,14 mgL^{-1}at (standard 20 mgL^{-1}), Nitrate at 0,41-0,62 (standard 0,008 mgL^{-1}), and Phosphate at 1,40-1,14 mgL^{-1} (standard 0,015 mgL^{-1}), TDS 2281,67-2535,67 (standard 500 mgL^{-1}), and TSS 75,87-81,20 (standard 20 mgL^{-1}).

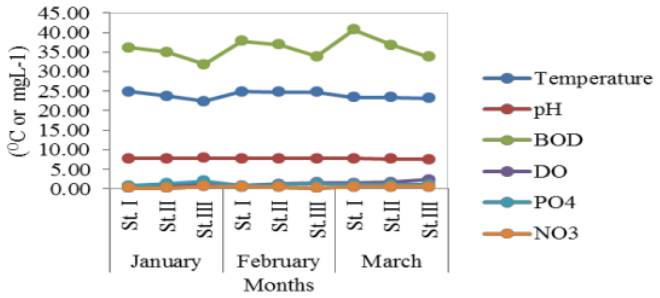


Figure 2. Changes of water temperature, pH, BOD, DO, phosphate and nitrate in Sibelis

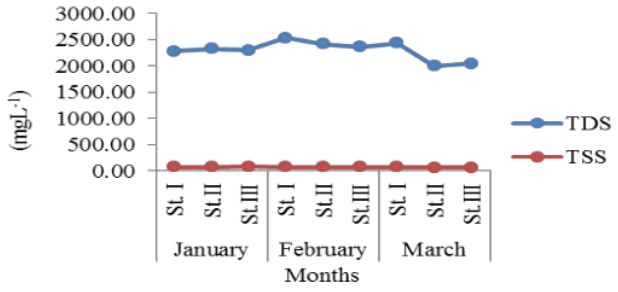


Figure 3. Changes parameters of TDS and TSS in Sibelis

On the other hand, only four water quality parameters in Kemiri exceed the ministry's standard threshold namely TDS, TSS, Nitrate, and Phosphate. The measurement results of the three parameters are as follows: TDS 499,33-675,00 (standard 500 mgL^{-1}), TSS 79,27-81,03 (standard 20 mgL^{-1}), Nitrate 2,11-1,68 (standard 0,008 mgL^{-1}) and PO_4 at range 2,08 to 1,96 mgL^{-1} (standard 0,015 mgL^{-1}). See Figure 4 and 5.

The results of this study indicate that the quality of water in the rainy season from Kemiri is relatively better compared to the quality of Sibelis estuary water. This condition is likely because the source of pollutants from Sibelis is greater than Kemiri. The difference between the two is in the dissolved oxygen content and BOD_5 which shows low DO and high BOD_5 in Sibelis. One source of pollutants is thought to be fish fillet waste, which according to the production process still does not pay attention to the impact on the environment [25]. Although the Waste Water Treatment Plant (IPAL) has been prepared, it has not been optimally utilized. The high value of BOD_5 indicates the high level of organic waste entering the waters also thought to originate from agricultural and domestic waste [26].

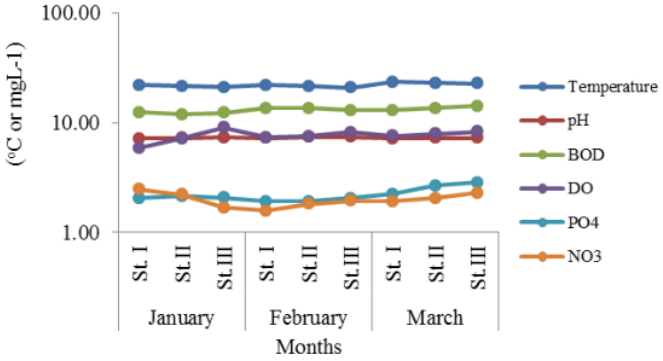


Figure 4. Changes of water temperature, pH, BOD_5, DO, phosphate and nitrate in Kemiri

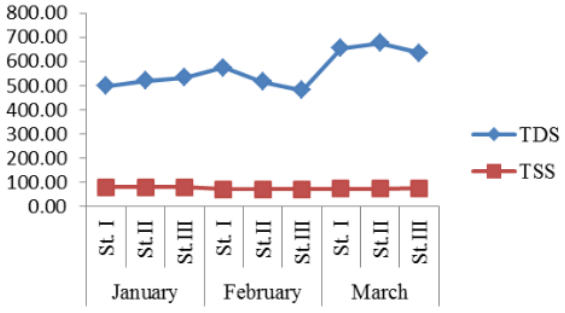


Figure 5. Changes parameters of TDS and TSS in Kemiri

The nutrient content of nitrate and phosphate was found to exceed quality standards both in Sibelis and in Kemiri. This condition is thought to be caused by the existence of milkfish farming in the watersheds of the two estuaries. As reported that fish farming activities also affect the nutrient content in the waters. The increase in nutrient content is due to the use of excess fish or shrimp feed in

aquaculture. This is evident from the higher nitrate and phosphate concentrations in Kemiri than in Sibelis, i.e 2.08 mgL^{-1} and 2.11 mgL^{-1}comparing Sibelis at 1.40 mgL^{-1} and 0.41 mgL^{-1}, respectively, because the pond area in Kemiri is wider.

3.2. NSF-WQI Index

Water Quality Index has been developing since 1965 and is widely used in various countries to see the quality of water, with various variations based on physical, chemical and biological measurements [27]. In Canada, for example, using the Canadian Council of Ministers of the Environment Water Quality Index [28]. Although the use of WQI with some water quality parameters is still considered imperfect however, this method is widely applied [29,30,31]

Based on the NSF-WQI score, there was an increase in trends in Sibelis estuary from January to March 2019 (48.02 to 51.25) at the level of 49.61 including the poor quality category. On the other hand, in Kemiri estuary there was a decline in trends (62.36 to 61.59) at the level of 63.31 included in the category of moderate quality (Figure 6). These results also show that the water quality of the waters of the Kemiri estuary is relatively better compared to the Sibelis estuary. This condition is also in line with the results of comparing the values of water quality parameters when viewed from the quality standards of the Ministry of Environment.

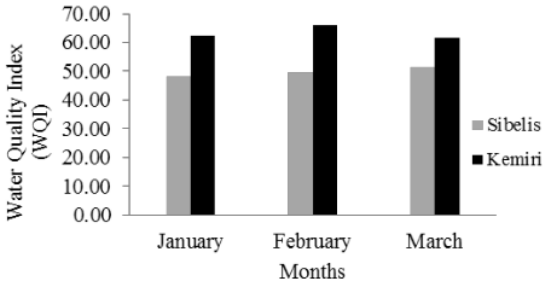


Figure 6. Rate of WQI value in Sibelis and Kemiri estuaries.

In Sibelis, WQI values show an upward trend with the same pattern for each station, except station I which is decreasing and the trend is stable at 50.96. See Figure 7. The increase in WQI value can be influenced by many of the standard parameters, such as TDS, TSS, BOD_5, DO, Nitrate and Phosphate. Based on time series data, TDS, TSS, and PO_4 have a linear relationship with WQI values. A decrease of three parameters can increase the value of WQI from January to March 2019. This can affect the index to increase during the study.

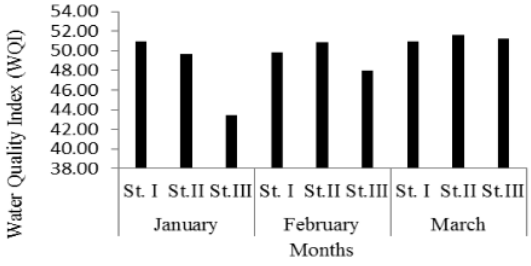


Figure 7. WQI value in Sibelis

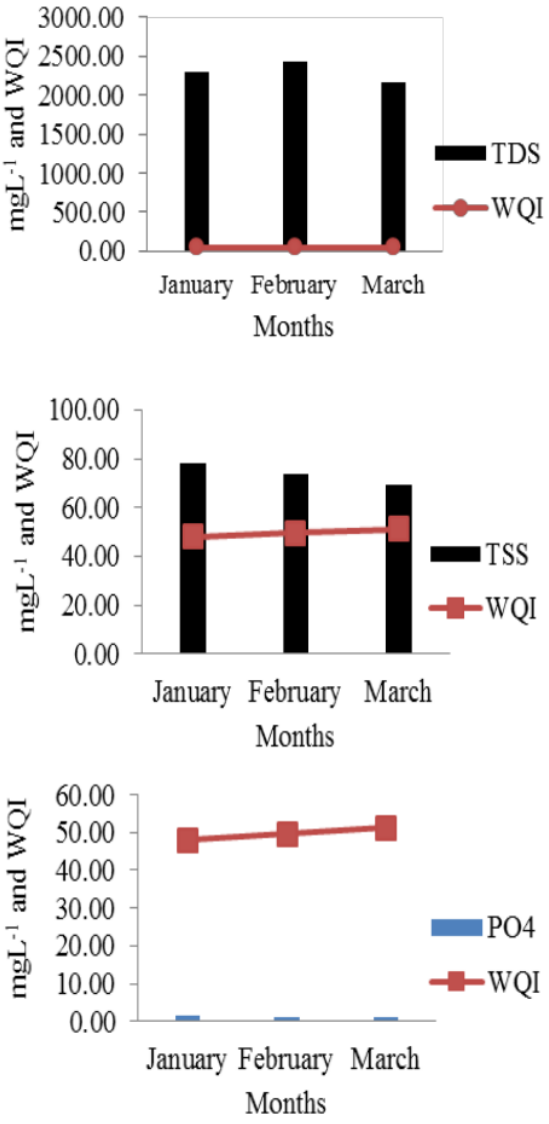


Figure 8. Changes in TDS (a), TSS (b) and PO4(c) values in relation with WQI in Sibelis

Whereas in Kemiri, the WQI value showed a decreasing trend except for station I which tended to rise to 69.66 (Figure 9). The downward trend can also be influenced by many parameters such as TDS, TSS, nitrate, and phosphate. Based on time series data, TDS has a linear relationship with the WQI value. There is an increase in the TDS parameters and follow the decline in WQI values from January to March 2019 (Figure 10). This can affect the index to decrease during the study.

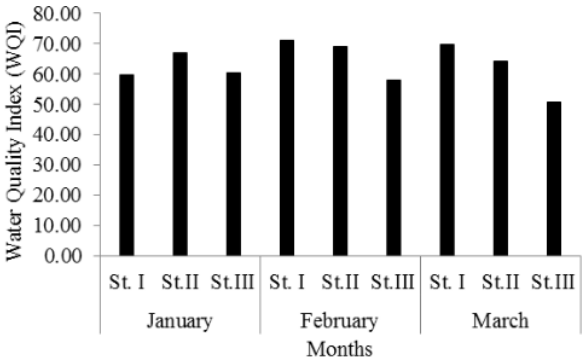


Figure 9. Changes in WQI at each station in Kemiri

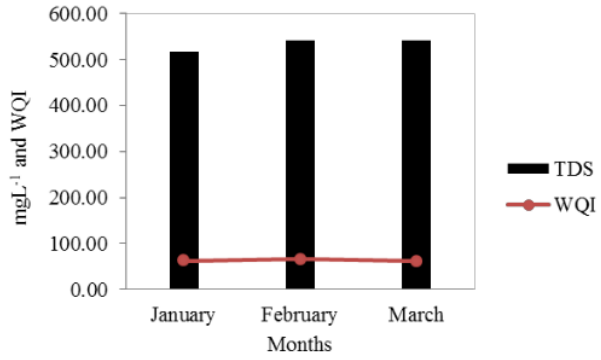


Figure 10. TDS relation with WQI value in Kemiri

4. Conclusion

Water quality in the rainy season at the Kemiri estuary is relatively better compared to the Sibelis estuary. There are 4 and 6 parameters of water quality at the Kemiri and Sibelis estuaries that exceed the quality standards of the Ministry of Environment Regulation 2004. This is also evident from the NSF-WQI values at the Kemiri estuary that is higher than the Sibelis estuary.

Acknowledgment

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