Poll Res. 40 (2) : 450-456 (2021)

ISSN 0257–8050

PREDICTION OF WATER QUALITY STATUS IN SURABAYA RIVER WITH DYNAMIC SYSTEM METHOD AT SEPANJANG BRIDGE MONITORING STATION, SURABAYA

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(Received 22 September, 2020; accepted 22 October, 2020)

ABSTRACT

This study aims to predict the water quality of the Surabaya River and determine its water quality status at the Sepanjang Bridge. Dynamic System (Stella) software was used to predict the water quality of the Surabaya River. The water quality status of the Surabaya River was determined by the Storet method or the Pollution Index method. Data obtained from the Sepanjang Bridge monitoring station in the Surabaya River showed that the average concentration of DO, BOD, TSS, and PO_4 parameters exceeded the quality standard, while COD and NO_3 parameters were still below the acceptable water quality standards in Indonesia. Based on the Storet score, the status of water quality is moderately polluted from 2017 to 2021 and 2023. In 2022, it is categorized as highly polluted. Meanwhile, based on the Pollution Index, water quality in 2017-2023 is in polluted category. This is shown bythese results: the majority of TSS was in the highly polluted category; The majority of BOD, COD, DO, and PO_4 are in the lightly polluted category; NO_3 majority in either category.

KEY WORDS : Water quality status, Surabaya River, Dynamic System, Storet, Pollution Index.

INTRODUCTION

In Surabaya, six drinking water treatment plants serve the drinking water for its three million in habitants. Three Drinking Water Treatment Plants (IPAM) in Ngageland three Drinking Water Treatment Plants (IPAM) in Karangpilangprocess water from the Surabaya River. The Karangpilang installation is located in the middle of the Surabaya River.At the same time, the Ngagel installation is in the downstream of the Surabaya River, which is prone to receive the industrial, domestic, and agricultural wastewater disposal. Around mid-1976s, the cases of water pollution in the Surabaya River began to occur. Regional Water Supply Company of Surabaya (PDAM) stopped its drinking water production (Anonymous, 1976) because there were many industries located around Kali Surabaya. The water had been contaminated which reduced water quality of Surabaya River. In the dry season, the water flow was small, which resulted in the death of many fish and made the quality of drinking water in Surabaya decreasing. Several studies related to water pollution in the Surabaya River had been conducted from 1985 to 2014 (Anonymous, 1985; Anonymous, 1991; Anonymous, 1996; Anonymous, 2000; Anonymous, 2008; Trisnawati and Masduqi, 2014). Razif *et al*. (2018) have examined the prediction of water quality status with a dynamic system for IPAM Karangpilang. Based on the STORET score, the study concluded that the water quality status at the Karangpilang IPAM Intake was categorized as highly polluted from 2011 to 2020. Razif and Persada (2016) used Structural Equation Modeling (SEM) to determine the correlation between discharge and water quality parameters at IPAM Karangpilang intake and IPAM Ngagel intake. Razif *et al. (*2015a) employed a dynamic system to predict fluctuations in wastewater in Surabaya city malls. Razif *et al.* (2015b) utilized a dynamic system to assess the impact of BOD, COD, and TSS fluctuations in the Surabaya River. Fulazzaky (2010) stated that the decline in the quality of Citarum river water has increased from year to year due to the increasing load of pollutants discharged without processing from the upstream Bandung area. According to Morihama (2012), one of the most important causes of poor river water quality in Brazilian cities is the low collection efficiency of the sewer system due to unplanned interconnection with the rainwater drainage system. Meanwhile, according to Lin *et al.* (2010), the main source of pollution in Kaohsiung City, Taiwan, comes from municipal, agricultural, and industrial wastewater. Sung Min Cha *et al.* (2009) explained that BOD5 in Korea's Yeongsan River was very high during the dry period of spring (April, May, and June). Then, it decreased during the rainy period of summer (July, August, and September) due to the dilution effect of rainfall. Several studies on river water pollution in large and small cities in many countries have also been conducted, so that river water is not suitable for consumption (Jiang *et al*., 2018; Tedford *et al.,* 2018; Wu *et al*., 2018; Ewaid *et al*., 2018; Sado -Inamura and Fukushi, 2018; Achupallas *et al.,* 2018). Cities located in the downstream of rivers tend to have low water quality due to domestic waste (Deng *et al.,* 2017; Luo *et al.*, 2018; Morihama *et al.*, 2012; Edokpayi *et al.*, 2016; Zhao *et al.*, 2018). Heavy metal pollution is also found in many rivers (Kong *et al.*, 2018; Lu *et al.*, 2018; Islam *et al.*, 2018; Duncan *et al*., 2018; Tang *et al.*, 2018; Withanachchi *et al.*, 2018; Nambatingar *et al.*, 2017). The various research results above show that river water pollution occurs in almost cities and towns located in the downstream in all parts of the world. It indicates that the Wastewater Treatment Plant does not function properly from the source of pollution so that almost all liquid waste disposed pollutes the river water from upstream to downstream.

MATERIALS AND METHODS

Data Collection Method

Data collection were carried out by collecting secondary data from the Environmental Agency of East Java Province. The dataincluded monthly monitoring data of Surabaya River water quality for three years (2014 - 2016) and monitoring data of Surabaya River water flow for three years (2014 - 2016) at the Sepanjang Bridge monitoring station.

Data Processing Method

Data processing were begun by entering the Surabaya River water quality parameter data (DO, BOD, COD, TSS, PO_4, and NO_3) for three years (2014-2016) at the Sepanjang Bridge monitoring station into the Stella Program. The subsequent data processing was calculating the water quality status data of the Surabaya River using the Storet method and the Pollution Index. Then, a comparison was made between the results obtained and the water quality standards regulated in the legislation. In principle, the Storet method is to compare water quality data with water quality standards that are adjusted to their designation determine the water quality status (Table 1). The way to determine the level of water quality is by classifying water quality into four classes, namely:

1. Class A : very good, score 0 → meet quality standards
2. Class B : good, score -1 s/d -10 → lightly polluted
3. Class C : fair, score -11 s/d -30 → moderately polluted
4. Class D : poor, score ≤ -31 → highly polluted

This Pollution Index (PI) method can directly relate the pollution level to the river use with the value of certain parameters.

Evaluation of the PI value is

$0 \leq PIj \leq 1.0$ → Meet quality standards (good condition)
$1.0 < PIj \leq 5.0$ → Lightly polluted
$5.0 < PIj \leq 10$ → Moderately polluted
$PIj > 10$ → Highly polluted

RESULTS AND DISCUSSION

The results of concentration predictions for TSS, BOD, COD, DO, PO_4, and NO_3 parameters using a dynamic system (Stella) can be seen in Figures 1 to 6. Figures 1 to 6 show that the average concentration of DO, BOD, TSS, and PO_4 parameters exceeds the water quality standard, while for COD and NO_3 parameters, the average concentration is still below the water quality standard. It may be due to differences in thepollution characteristics of the Surabaya river, which are from domestic wastewater, agriculture, and industrial activities. Domestic, agricultural, and industrial wastewater also fluctuates in terms of characteristics and concentration (Razif *et al.*, 2015a; Razif *et al.*, 2015b).

The Storet Index is an instrument to measure the contamination quality of a water body by using comparison data between water quality data and water quality standards adjusted for its purpose to determine the water quality status (Anonymous, 2003). The predicted water quality conditions, from 2017 to 2023 at the Sepanjang Bridge Monitoring Station,according to the Storet Index, are shown in Table 2. Based on the Storet Index above, the water quality status at Sepanjang Bridge is moderately

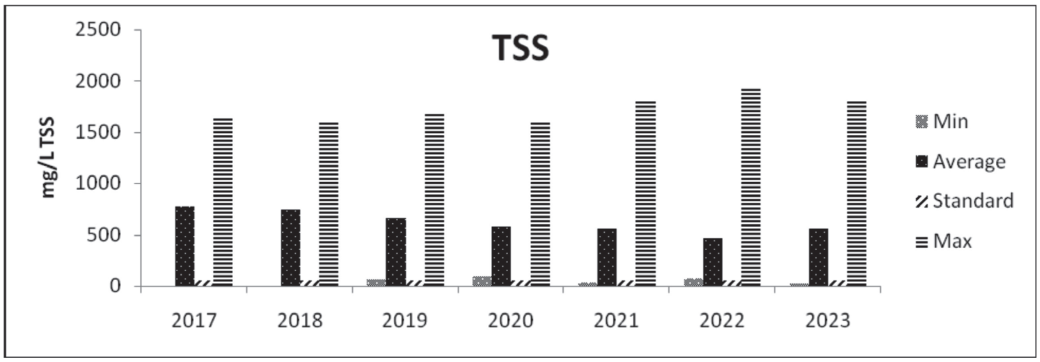

Fig. 1. Results of TSS parameter prediction at Sepanjang Bridge in 2017 - 2023

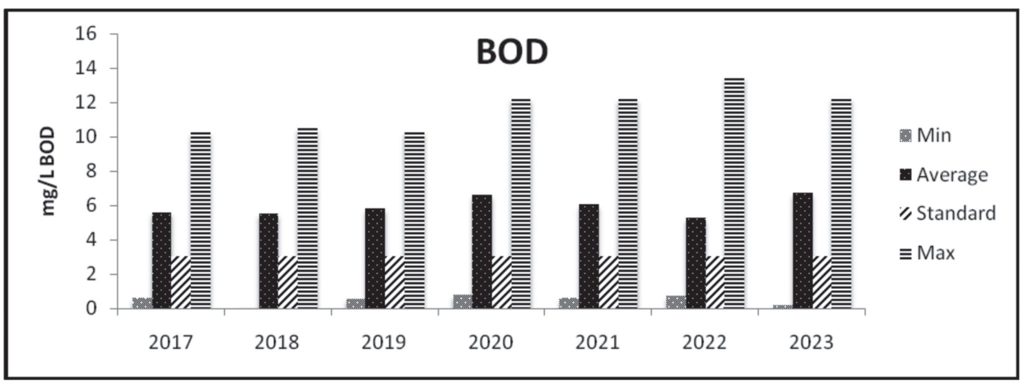

Fig. 2. Results of BOD parameter prediction at Sepanjang Bridge in 2017 – 2023

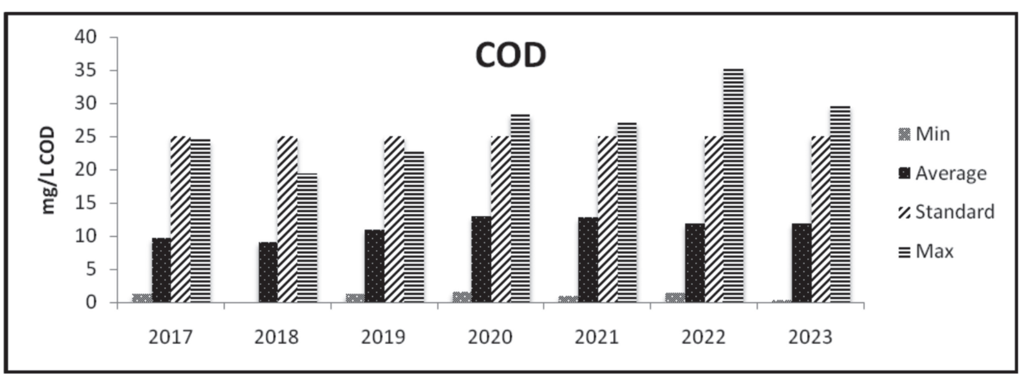

Fig. 3. Results of COD parameter prediction at Sepanjang Bridge in 2017 - 2023

polluted, and in 2022 it will behighly polluted. Research conducted at the monitoring station, which is located in the upstream of the Sepanjang Bridge, also resulted in a highly polluted status (Priyono *et al.*, 2010). The status of highly and moderately polluted water quality can still be improved by implementing policies, which have been done in the Songhua River in China (Wei *et al.*, 2017) and in the Houjing River in Taiwan (Lin *et al.*, 2010). River managers need to prepare the most effective pollution control methods to be implemented (Wang *et al.*, 2017). Pollution methods are also used in Indonesia to determine the status of water quality (Anonymous, 2003). Pollution Index method has advantage to determine the status of river water quality that is monitored with only one data series. Thus, it requires a relatively low cost and less time. However, because the calculated data are single

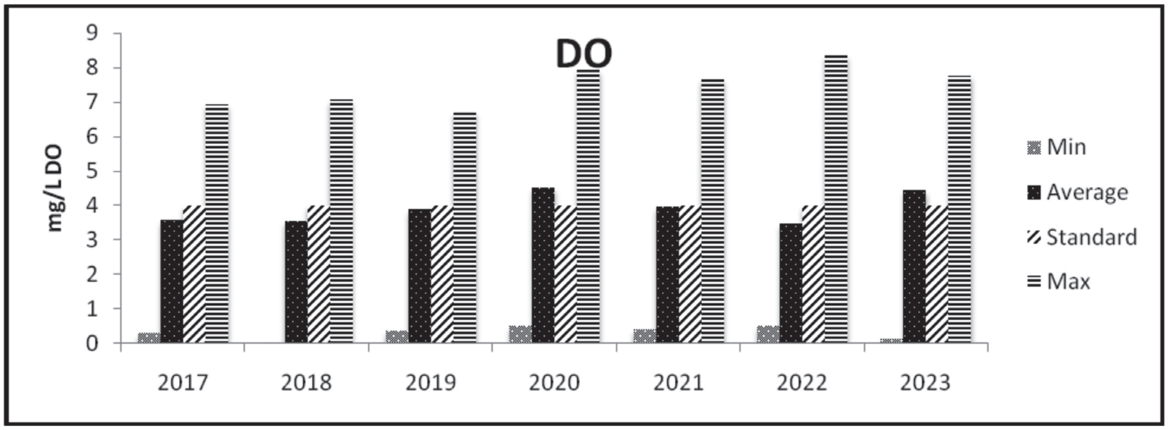

Fig. 4. Results of DO parameter prediction at Sepanjang Bridge in 2017 - 2023

Table 1. The value system determination of the water quality status

Number of examples [1)]	Score	Parameter		
		Physics	Chemistry	Biology
<10	MaximumMinimumAverage	-1-1-3	-2-2-6	-3-3-9
>10	MaximumMinimumAverage	-2-2-6	-4-4-12	-6-6-18

Source: Carter (1977)

Note: [1] The number of parameters used for determining the water quality status

Table 2. Storet Index from 2017 to 2023

Parameter	2017	2018	2019	2020	2021	2022	2023
TSS	-4	-4	-5	-5	-4	-5	-4
BOD	-8	-8	-8	-8	-8	-8	-8
COD	0	0	0	-2	-2	-2	-2
DO	-8	-8	-8	-2	-8	-8	-2
PO_4	-8	-8	-8	-8	-8	-8	-8
NO_3	0	0	0	0	0	0	0
Total	-28	-28	-29	-25	-30	-31	-24

Table 3 Pollution Index from 2017 to 2023

Parameter	2017	2018	2019	2020	2021	2022	2023
TSS	25.74	24.90	25.70	24.05	26.88	28.23	26.79
BOD	2.75	2.80	2.79	3.27	3.21	3.40	3.30
COD	0.74	0.61	0.71	0.88	0.85	1.05	0.90
DO	1.38	1.40	1.37	1.61	1.53	1.60	1.58
PO_4	2.47	2.50	2.45	2.89	2.74	2.87	2.85
NO_3	0.28	0.28	0.28	0.32	0.32	0.34	0.33

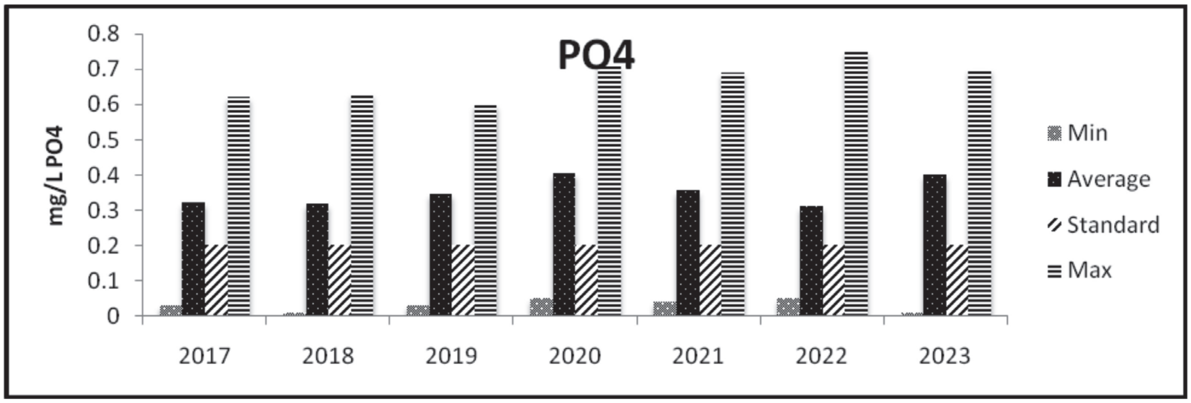

Fig. 5. Results of the PO_4 parameter prediction at the Sepanjang Bridge Monitoring Station in 2017 - 2023

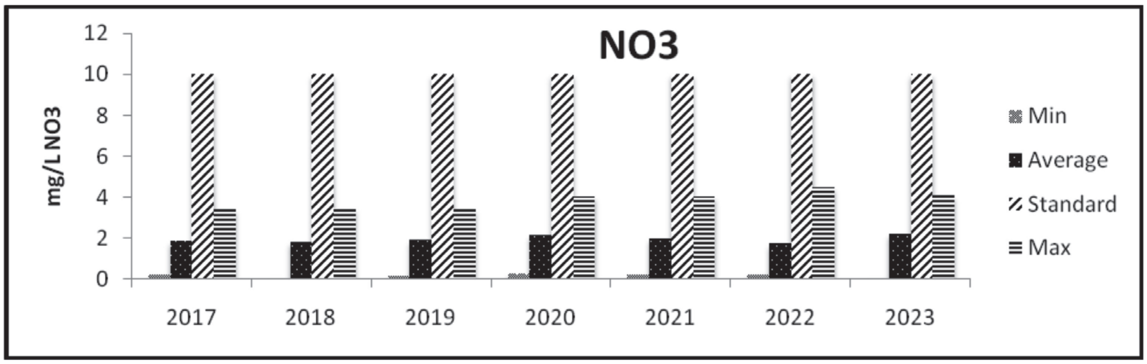

Fig. 6. The results of the NO_3 parameter prediction at the Sepanjang Bridge Monitoring Station in 2017 - 2023

data, it does not adequately represent the actual river quality conditions. Measurements with other single data (different times) at the same location often result in different water quality status. To avoid different interpretations regarding the status of monitored river water quality, we used the average annual water quality data as single data. The predicted water quality conditions from 2017 to 2023 at the Sepanjang Bridge Monitoring Station, according to the Pollution Index, are shown in Table 3. Based on the Pollution Index Value in Table 3, it can be concluded that: TSS is in the heavily polluted category, BOD is in the lightly polluted category, COD is in a good category, DO is in the lightly polluted category, PO_4 is in the lightly polluted category, and NO_3 is in a good category. The improved condition of NO_3 parameters in the downstream river is like that of the Yellow River in China (Chen *et al.,* 2020).

CONCLUSION

Prediction of river water quality based on dynamic system software at the Sepanjang Bridge monitoring station in the upstream intake of IPAM Ngagel Surabaya City shows that the average concentrations of DO, BOD, TSS and PO_4 parameters exceed water quality standards. While for COD and NO_3 parameters, the average concentrations are still below the water quality standards. Based on the Storet score, the status of water quality at the Sepanjang Bridge monitoring station is categorized as moderately polluted in 2017, 2018, 2019, 2020, 2021, and 2023, and in 2022 it is categorized as heavily polluted. Based on the Pollution Index, the water quality results of the Surabaya River (SepanjangBridge Monitoring Station) from 2017 to 2023 are: TSS is in the heavily polluted category; BOD, COD, DO, and PO_4 are in the lightly polluted category; NO_3 is in a good category.

ACKNOWLEDGMENT

The authors express their gratitude to the Directorate of Research and Community Service, Ministry of Higher Education and Culture for funding this research through the Postgraduate

Masters Research scheme. Also, the authors thank the LL Dikti Region VII and LPPM ITATS who participated in the process of this research funding.

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