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CORRELATION OF WATER DISCHARGE WITH WATER QUALITY PARAMETERS USING SEM IN SEPANJANG BRIDGE MONITORING STATION AND GUNUNGSARI DAM OF SURABAYA RIVER, INDONESIA

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ABSTRACT

The purpose of this research is to examine the effect of river water discharge on water quality parameters of the Surabaya River at the monitoring station of the Sepanjang Bridge and Gunungsari Dam at the upstream intake of Ngagel Drinking Water Treatment Plant (IPAM).The parameters included DO, BOD, COD, TSS, PO_4, NO_3, and were measured using Structural Equation Modeling (SEM) software. Based on the descriptive analysis of the Surabaya River water quality in 2013-2017, it showed that the average concentration of BOD, COD, DO, TSS, PO_4 parameters exceeded the water quality standard, while for NO_3 the average value was still below the water quality standard. The analysis used by SEM showed that water discharge had a positive effect on DO and TSS parameters. If there is an increase in discharge with one standard deviation, the DO and TSS values will increase. Whereas the effect of water discharge on the parameters BOD, COD, PO_4, and NO_3 showed the opposite effect.If there is an increase in discharge with one standard deviation, the values of BOD, COD, PO_4, NO_3 will decrease.

KEY WORDS : Discharge, Water parameters, Structural equation modeling

INTRODUCTION

Water quality contamination of the Surabaya River occurred before 1985, based on a study report conducted by PT Encona (Anonymous, 1985). Subsequent studies (Anonymous, 1991; Anonymous, 1996; Anonymous, 2000; Anonymous 2008; Trisnawati and Masduqi, 2014) indicate that the water quality of the Surabaya River has been contaminated, and this pollution is still ongoing today. Research conducted by Razif (2018) concluded that at the Krangpilang Intake, the Surabaya River water quality was predicted to be heavily polluted for 2016-2020 based on the STORET score. Currently, the capacity of the Ngagel I water treatment plant is 1800 liters per second, Ngagel II is 1000 liters per second, and Ngagel III is 1750 liters per second (Said and Hartaja, 2018). Since their construction and operation, IPAM Ngagel I, II, and III have used Surabaya River water as their raw water. If the water discharge supplied to the Karang Pilang IPAM is strongly influenced by the water regulation at the Mlirip floodgate, Perning Dam, and Gunungsari Dam, then the water discharge supplied to the Ngagel IPAM is highly dependent on the water discharge regulation at the Gunungsari and Jagir Dam. Several researchers have examined the relationship between water discharge and water quality parameters and water quality conditions in several rivers in Indonesia. Razif *et al*. (2015) stated that there was one positive parameter, while the other five were negative in the study of the water parameters effect on water discharge in the Surabaya River. Pohan *et al*. (2016) argued that the COD parameters of water quality in the Kupang Riverat some points had exceeded the quality standard, while the BOD parameters at all points had exceeded the required quality standards. Patang (2019) explained that the Jeneberang River in Gowa Regency, Indonesia had high phosphate, nitrogen, and eutrophication. Triaji *et al.* (2017) and Baharudin (2013) stated that water quality in the Porong River was classified as moderate. Suntoyo (2015) revealed that at high tide, the distribution of water quality parameters would be small around the estuary, while at low tide, the quality parameters would be greater at the estuary of the Porong River. Andara *et al.* (2014) examined the Klampisan Semarang River and concluded that the highest TSS content was in February 2014 (45 mg/l), the highest BOD was in February 2014 (20.69 mg/l), and the highest COD was in January 2014 (73, 5 mg/l). Barkah *et al*. (2005) stated that population growth, livestock, and compost heaps in the Sigeleng River, Brebes, Central Java, resulted in water pollution. Research in other countries also indicates river water contamination (Jiang *et al*., 2018; Wu *et al.,* 2018; Chatanga *et al.,* 2019; Murphy, 2019). There are several published studies on the application of Structural Equation Modeling (SEM), such as those conducted by Zuhairoh (2012); Chandra, (2015); Yasar *et al.* (2016); Jaijit *et al.* (2018); and Khunsoonthornkit *et al.* (2018).

MATERIALS AND METHODS

Data Collection Method

Data collection was carried out by collecting secondary data from the Environmental Office of East Java Province. The data were monthly monitoring data of Surabaya River water quality for five years (2013 - 2017) and monitoring data of Surabaya River water discharge during five years (2013 - 2017) at the monitoring station for the Sepanjang Bridge and Gunungsari Dam.

Data Processing Method

The calculation was done using Structural Equation Modeling (SEM) software. Then, the effect of discharge on parameters DO, BOD, COD, TSS, PO_4, and NO_3 at the monitoring station of the Sepanjang Bridge and Gunungsari Dam upstream intake of the Ngagel IPAM could be found out.

RESULTS AND DISCUSSION

In this study, to see the effect of water discharge with water quality parameters including DO, BOD, COD, TSS, PO_4 and NO_3, we carried out a descriptive analysis first as depicted in Table 1. Then, the modeling was conducted.

From Table 1, it can be seen that the average parameters of BOD, COD, DO, TSS, PO_4does not meet the requirements, compared with the drinking water quality standards of class 1. This result is not different from the results of previous studies conducted for the years 2011-2013 (Trisnawati and Masduqi, 2014). The monitoring station of the Sepanjang Bridge and Gunungsari Dam is located downstream of the Surabaya River. In general, there is a tendency for the river water quality in the

Table 1. Descriptive Analysis of Discharge and Water Parameters in the Panjang Bridge and Gunungsari Dam (2013-2017)

	N	Range	Min	Max	Mean	Std. Deviation	Variants	Class I Water Quality Standards
Debit (m^3/s)	120	87.73	6.00	93.73	46.3323	22.16603	491.333	-
BOD (mg/l)	120	20.41	2.39	22.80	5.5436	3.07493	9.455	2
COD (mg/l)	120	53.40	4.80	58.20	14.3313	9.93500	98.704	10
DO (mg/l)	120	11.00	0.00	11.00	4.4126	1.74431	3.043	6
TSS (mg/l)	120	1166.40	9.60	1176.00	221.4975	245.65406	60345.920	50
PO_4 (mg/l)	120	0.50	0.10	0.60	0.2220	0.09792	0.010	0.2
NO_3 (mg/l)	120	3.69	0.01	3.70	1.8427	0.73208	0.536	10

downstream to decline compared to the upstream (Pohan *et al.*, 2016).

The structural model of water discharge on water parameters is shown in Figure 1. The details of the hypothesis for the SEM model are defined as follows: H1: water discharge has a positive effect on BOD, H2: water discharge has a positive effect on COD, H3: water discharge has a positive effect on DO, H4: water discharge has a positive effect on TSS, H5: water discharge has a positive effect on PO_4, H6: water discharge has a positive effect on NO_3. The results of SEM software are shown in Tables 2, 3, 4 and 5. From Tables 2 and 3, it can be seen that not all hypotheses are accepted; some are rejected.

DISCUSSION

From Tables 2 and 3, the hypothesis of DO and TSS parameters are accepted, while the hypothesis of COD, BOD, NO_3 and PO_4 parameters are rejected. To see the effect of the Beta coefficient, we analyzed the Beta and Standard Deviation values , as shown in Tables 4 and 5. From Tables 4 and 5, it can be seen that only DO and TSS parameters have positive Beta coefficients, while COD, BOD, NO_3 and PO_4 parameters have a negativeBeta coefficient. As the implication, an increase in discharge of 1000 m^3/s can make an increase of 0.63 mg/l DO at Sepanjang Bridge, and an increase in discharge of 1000 m^3/s can make an increase of 0.315 mg/l DOat the Gunungsari Dam. Furthermore, an increase in discharge of 1000 $m^3/$ s can make an increase of 73920 mg/l TSS at Sepanjang Bridge, and an increase in discharge of 1000 m^3/s can make an increase of 43332 mg/l TSS at Gunungsari Dam. As for the COD, BOD, NO_3 and PO_4 parameters, if there

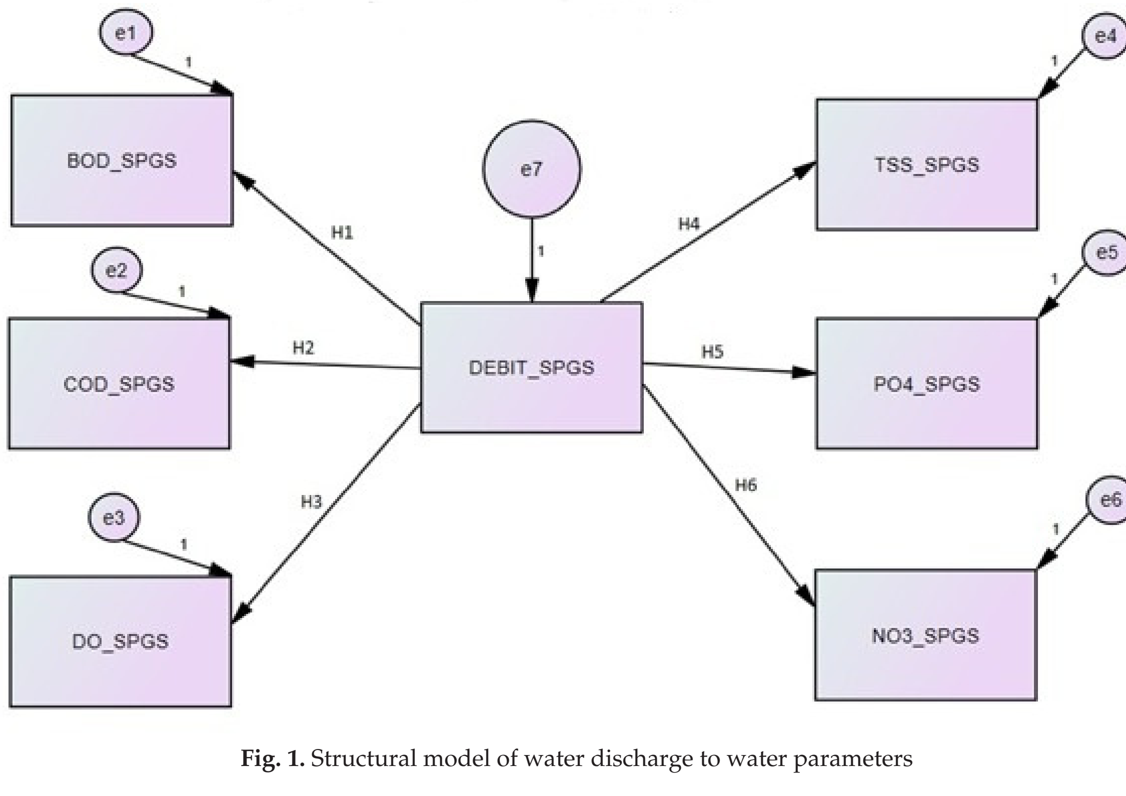

Fig. 1. Structural model of water discharge to water parameters

Table 2. Hypothesis results of the effect of discharge on water parameters at Sepanjang Bridge

Parameter	Correlation	Hypothesis	Note
BOD (mg/l)	-0.02	H1:Rejected	Reverse Value
COD (mg/l)	-0.07	H2: Rejected	Reverse Value
DO (mg/l)	0.11	H3:Accepted	-
TSS (mg/l)	0.47	H4: Accepted	-
PO_4 (mg/l)	-0.18	H5: Rejected	Reverse Value
NO_3 (mg/l)	-0.10	H6: Rejected	Reverse Value

is an increase in discharge with one standard deviation, then the values of BOD, COD, PO_4, NO_3 will decrease. In general, river water quality improves because river water discharge in the rainy season increases compared to in the dry season (Cha *et al.*, 2009). The increase in discharge generally allows the increaseof reaeration and the DO content in river water. However, this general condition does not occur for the TSS parameter because of the Surabaya River discharge regulation with the Mlirip and Perning Dam in the upstream and the Gunungsari Dam and Jagir Dam in the downstream. If the water discharge of the Brantas River in the upstream of the Surabaya River increases in the rainy season, then the excess water discharge will flow to the Porong River with the arrangement at the Mlirip floodgate. Thus, the water discharge between the rainy season and the dry season can be relatively maintained to supply the needs of raw water for the Karangpilang and Ngagel IPAM. After the Mlirip floodgate, there is also the Perning Dam in the upstream. The location of the Surabaya River between Perning and Gunungsari Dam is like Long Storage, which ensures the availability of water discharge for the Karang Pilang IPAM throughout the year. This Long Storage allows the occurrence of TSS deposits and will be resuspended back to river water when the river water discharge increases. Brantas River is in the upstream of the Surabaya River and passes throughthefour administrative areas, namely the City of Surabaya, Sidoarjo Regency, Gresik Regency, and Mojokerto Regency that is directly adjacent to the Surabaya River. The improvement of water quality management of the Surabaya River should use a comprehensive approach that is a combination of objective administration and management of the Brantas watershed as practiced in China (Deng *et al.*, 2017). Besides, in this study, not all water quality parameters are affected by water discharge.

Table 3. Hypothesis results of the effect of discharge on water parameters in the Gunungsari Dam

Parameter	Correlation	Hypothesis	Note
BOD (mg/l)	-0.01	H1: Rejected	Reverse Value
COD (mg/l)	-0.04	H2: Rejected	Reverse Value
DO (mg/l)	0.05	H3: Accepted	-
TSS (mg/l)	0.42	H4: Accepted	-
PO_4 (mg/l)	-0.34	H5: Rejected	Reverse Value
NO_3 (mg/l)	-0.03	H6: Rejected	Reverse Value

Table 4. Calculation of the Effect of Coefficients on the Sepanjang Bridge

Variable	Beta	Std. Dev	1 unit increase	100 m^3/s increase	1000 m^3/s increase
Debit (m^3/s)		22.17	22.170	100.000	1000.000
COD (mg/l)	-0.015	9.94	-0.149	-0.672	-6.723
DO (mg/l)	0.008	1.74	0.014	0.063	0.630
BOD (mg/l)	-0.002	3.07	-0.006	-0.028	-0.277
NO_3 (mg/l)	-0.003	0.73	-0.002	-0.010	-0.099
PO_4 (mg/l)	-0.001	0.10	0.000	0.000	-0.004
TSS (mg/l)	6.67	245.65	1638.806	7391.998	73919.984

Table 5. Calculation of the Effect of the Coefficient on the Gunungsari Dam

Variable	Beta	Std. Dev	1 unit increase	100 m^3/s increase	1000 m^3/s increase
Debit (m^3/s)		22.17	22.170	100.000	1000.000
COD (mg/l)	-0.024	9.94	-0.238	-1.076	-10.757
DO (mg/l)	0.004	1.74	0.007	0.031	0.315
BOD (mg/l)	-0.001	3.07	-0.003	-0.014	-0.139
NO_3 (mg/l)	-0.001	0.73	-0.001	-0.003	-0.033
PO_4 (mg/l)	-0.001	0.10	0.000	0.000	-0.004
TSS (mg/l)	3.91	245.65	960.679	4333.240	43332.404

Therefore, it is impossible to increase the discharge during the rainy season due to the arrangement at Mlirip floodgate. The Ngagel IPAM managers need to make pretreatment efforts so that the treated water can meet the standards of drinking water quality applied in Indonesia (Yudo and Said, 2019).

CONCLUSION

Based on the descriptive analysis in 2013-2017 at the monitoring station of Sepanjang Bridge and Gunungsari Dam, it showed that the average concentration of BOD, COD, DO, TSS, PO_4 parameters exceeded the water quality standard, while for the NO_3 parameter, the average value was still below the water quality standard. Analysis with Structural Equation Modeling (SEM) shows that water discharge has a positive effect on DO and TSS parameters.If there is an increase in discharge with one standard deviation, the DO and TSS values will increase. At the same time, the effect of water discharge on parameters BOD, COD, PO_4, and NO_3 showed the opposite effect. If there is an increase in discharge with one standard deviation, then the values of BOD, COD, PO_4, NO_3 will decrease.

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