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River water pollution condition in upper part of Brantas River and Bengawan Solo River

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Abstract. Wastewater and solid waste from both domestic and industry have been known to give burden on river water quality. Most of river water quality problem in Indonesia has start in the upper part of river due to anthropogenic activities, due to inappropriate land use management including the poor wastewater infrastructure. Base on Upper Citarum River Water pollution problem, it is interesting to study the other main river in Java Island. Bengawan Solo River and Brantas River were chosen as the sample in this study. Parameters assessed in this study are as follows: TSS, TDS, pH, DO, and hexavalent chromium. The status of river water quality are assess using STORET method. Based on (five) parameters, STORET value showed that in Brantas River, Pagerluyung monitoring point had the worst quality relatively compared to other monitoring point in Brantas River with exceeding copper, lead and tin compared to the stream standard in East Java Provincial Regulation No. 2 in 2008. Brantas River was categorized as lightly polluted river based on monitoring period 2011-2015 in 5 monitoring points, namely Pendem, Sengguruh, Kademangan, Meritjan and Kertosono.

Keywords: Brantas River, Bengawan Solo River, hexavalent chromium, polluted river, STORET, solid waste

1. Introduction

River pollution has been an immense problem to most rivers in Java Island. Pollution loads from human activities, both from domestic, industry, wastewater and solid waste. Previous study [4] reported that in several West and Central Java EPA monitoring location measured several exceeding parameters compared to stream standard. Citarum River, specifically in Koyod monitoring point, assessment of water quality monitoring during 2011 – 2014 showed that certain organic substances, heavy metal and *E. coli* exceeding the standards as written in city, provincial and/or government regulation. Bengawan Solo River lays on Central and East Java Province also had decreasing trend of DO value along 2011 to 2014. Registered industries in both rivers discharged wastewater into it, mostly textile industries. In Citarum river basin laid 74% of 561 textile industries while 41.5% of 253 textile industries in Bengawan Solo river basin.



Industrial wastewater is one of the contributing sector in river pollution. Prior researches [3], [4], [5] showed that wastewater was still toxic and exceeding the effluent standard when discharged into the river. Some industries were discharging wastewater that below the effluent standard with relatively high toxicity level [1].

This research was aimed to assess river water quality in upper part of river for two main rivers in Java Island Brantas and Bengawan. The assessment are using STORET method and water quality standard are using local government regulation and national regulation.

2. Research Method

Water quality data or upper part Brantas River and Bengawan Solo River collected from regular monitoring data in Provincial Environmental Protection Agency and data collected by field sampling in several monitoring point as showed in Table 1.

Table 1. Monitoring stations in Upper Citarum River, Bengawan Solo River and Brantas River.

No	River	Monitoring Points	Remarks	Stream Standards
1	Bengawan Solo River	BS-1: Outlet of Gajah Mungkur Dam	Wonogiri Regency	Government Regulation No. 81 in 2001
		BS-2: Taman Jurug Bridge	Surakarta City	
		BS-3: Jalan Arteri	Dusun Ngringgo Palur, Karanganyar Regency	
		BS-4: Kliwonan Bridge	Dusun Pulang, Masaran District, Sragen Regency	
		BS-5: Dusun Gawan Bridge	Tanon District, Sragen Regency	
2	Brantas River	Pendem Bridge	Malang City	<ul style="list-style-type: none"> • Government Regulation No.82/2001 • East Java Provincial Regulation No. 2/2008
		Dinoyo Bridge	Malang City	
		Gadang Bridge	Malang City	
		Sengguruh Bridge	Malang City	
		Kali Pare Bridge	Malang Regency	
		Kademangan Bridge	Blitar Regency	
		Ngujang Bridge	Tulungagung Regency	
		Meritjam Bridge	Kediri	
		Kertosono Bridge	Kediri	
		Ploso Bridge	Jombang Regency	
		Padangan Bridge	Mojokerto Regency	

Table 2. Scoring for STORET scoring.

Amount of Sample	Value	Parameter Type		
		Physical	Chemical	Biological
<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. Status of river based on STORET scoring.

Status	STORET Score
Lightly Polluted	-1 to -10
Moderately Polluted	-11 to -30
Heavily Polluted	> -30

3. Results and Discussion

3.1. Upper Bengawan Solo River

Bengawan Solo River located on two different provinces, namely Central Java and East Java, which also involves two different Provincial-EPA in monitoring program. This study is held in upper part of the river, under the authority of Central Java Provincial. Monitoring data collected from Provincial EPA are shown in Figure 1. During 2010-2015, showing that TDS and pH are comply to local government standard. The chromium hexavalent concentration exceeded the standard on May and July 2012 in BS-2 monitoring point. TSS value varies from 21 mg/L (Q1) to 42 mg/L (Q3), however the maximum TSS value is 519 mg/L as the peak in BS-1 on October 2013. The high concentration of TSS was also discovered on the same year in BS-2 (May and July), BS-3 (May and July) and BS-4 (May and July).

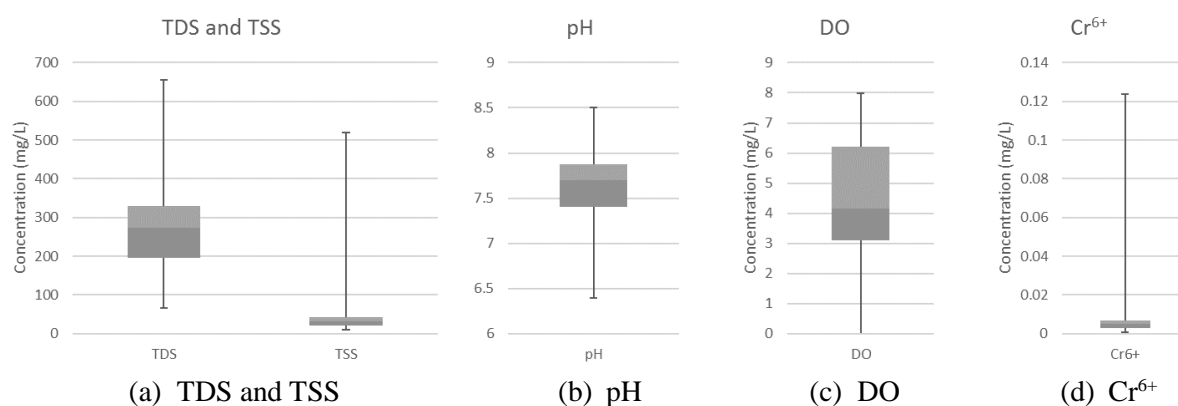


Figure 1. Bengawan Solo River monitoring results in BS-1, BS-2, BS-3, BS-4, BS-5
(Developed from Central Java EPA data, 2010 – 2015)

DO was the most frequent river water quality parameter that easily violated stream standard, showed the Figure 2 fluctuated DO value in each monitoring station, the lowest concentration identified at BS-4 reaching 0 mg/L on August 2011, September 2012 and November 2015.

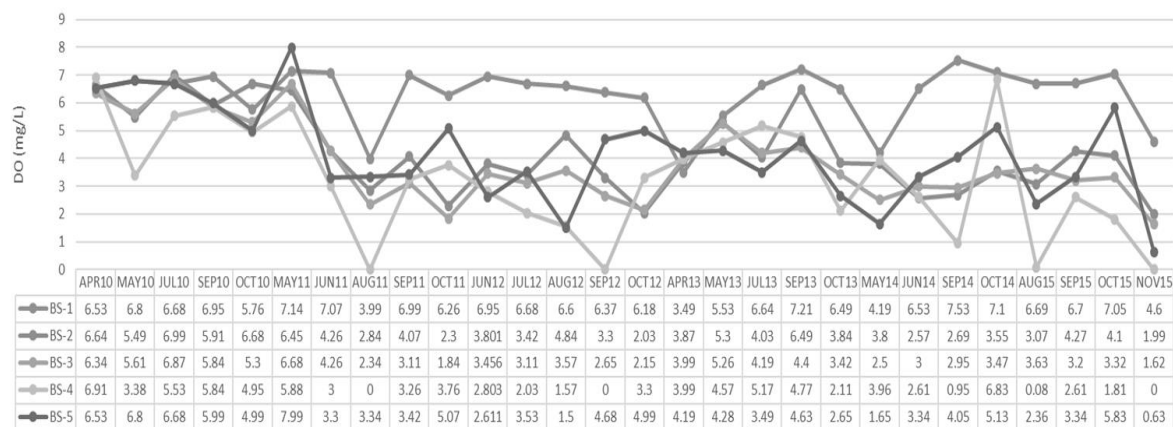


Figure 2. DO concentration in BS-5 monitoring point.
(Developed from Central Java EPA data, 2010 – 2015)

BS-5 and BS-4 were monitoring point which representing high pollution load from seven cities/regencies, namely Wonogiri, Sukoharjo, Klaten, Surakarta City, Karanganyar, Boyolali and Sragen. Compared to the first three monitoring stations (Figure 2). Based on STORET results on each monitoring point shows that BS-3 and BS-4 are the most polluted status, classified as moderately polluted (Table 5). The location of each monitoring point of Central Java Provincial EPA are shown in Figure 3.

Table 4. Exceeding parameters (percentage) during monitoring 2010 – 2015 of Bengawan Solo River (Central Java segment).

Parameters	Exceeding
TDS	0.00%
TSS	17.14%
pH	0.71%
DO	47.14%
Cr6+	1.43%

Table 5. Pollution level of Bengawan Solo River (Central Java segment) monitoring stations using STORET.

Points	Score	Pollution
BS-1	-6	Light
BS-2	-16	Moderate
BS-3	-24	Moderate
BS-4	-24	Moderate
BS-5	-12	Moderate

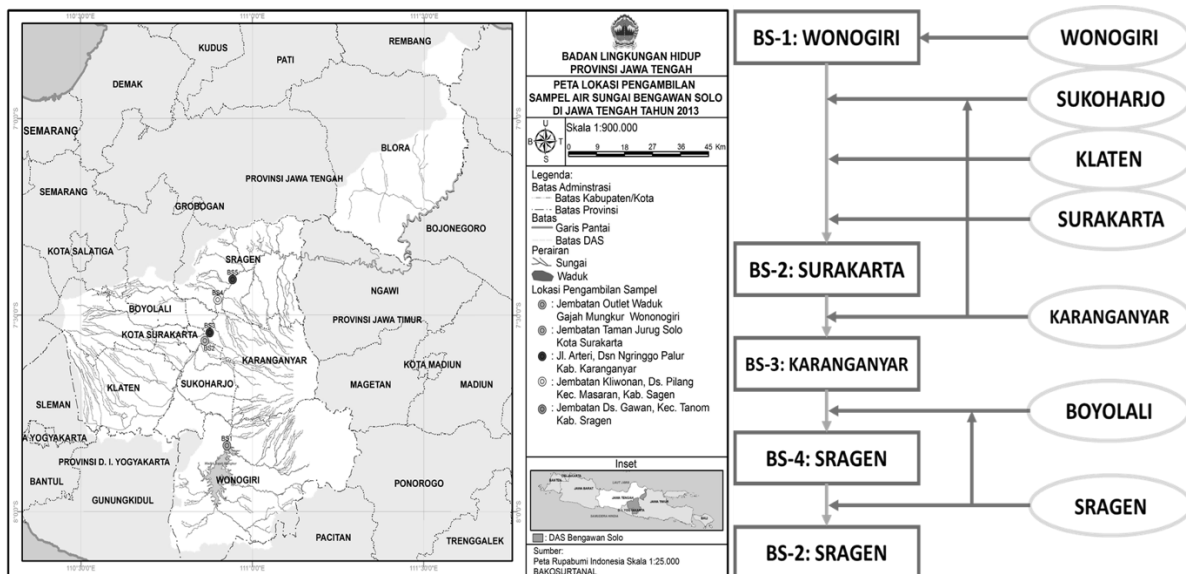


Figure 3. Upper Bengawan Solo River in Central Java Province (left) and simplified flowchart on the pollution load on each monitoring station (right).
(Modified from Central Java EPA, 2015)

3.2. Upper Brantas River

Brantas water basin (Figure 4) is the biggest river in East Java Province, and receiving waste water not only from 293 registered industrial sector, also agriculture and livestock as well. Agriculture and livestock will also contribute the pollution load into the river. From Upper Brantas River collected water sample are from 11 monitoring point along the upper part of the river as shown in Figure 4. Base on East Java EPA monitoring data on data from 2010-2015, parameter of TDS, TSS, pH and Chrome hexavalent are chose and analyzed using descriptive statistic to evaluate the most polluted point in Upper Brantas River. The mean and boxplot of data from 2010-2015 are shown in Figure 5. Most of the data are fluctuated, the worst condition identified in monitoring point of Kertosono up to Padangan as it the downstream of the studied river. Some high concentration of Chrome hexavalent are found in Padangan monitoring point. The pH range are still comply to river water standard regulation along the river from upstream to downstream.

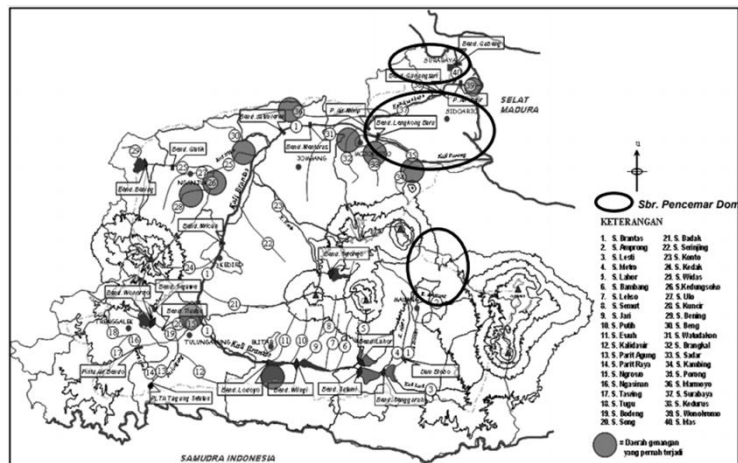


Figure 4. Brantas River water basin map.
(Source: Balai Besar Wilayah Sungai Brantas)

TDS and TSS concentration mostly were below the standard, except for once in June 2012 for both parameters. TDS and TSS value are in correlation to each other due to precipitation in mechanism in river water. Hexavalent chromium exceeding the standard at Kertosono (October 2013) and Padangan (April 2013).

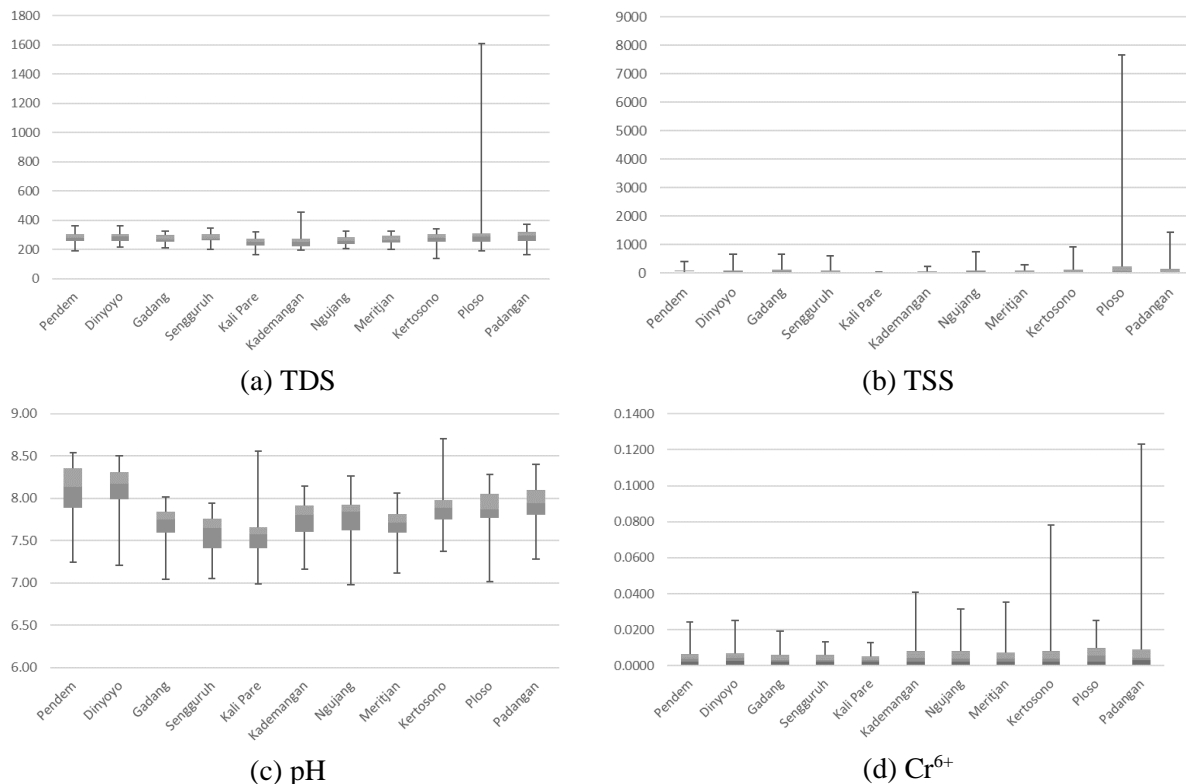


Figure 5. Several parameters on monitoring point during 2010-2015 in Brantas River
(Data source: East Java EPA, 2010-2015)

Table 6 showed the river water quality parameters that exceeding/violated the standard of river water quality. STORET results showed that based on stream standard of Regulation No. 82 in 2001 Upper Brantas River has been polluted in some monitoring point as showed in Table 7.

Table 6. Exceeding parameters (percentage) during 2010-2015 of Brantas River.

Parameters	Exceeding
TDS	0.17%
TSS	34.47%
pH	0.00%
DO	4.85%
Cr ⁶⁺	0.45%

Table 7. STORET result for Brantas River monitoring point.

Points	Score	Pollution
Jemb. Pendem	-14	Moderate
Jemb. Dinoyo	-10	Moderate
Jemb. Gadang	-10	Moderate
Jemb. Sengguruh	-10	Moderate
Jemb. Kali Pare	-16	Moderate
Jemb. Kademangan	-6	Light
Jemb. Ngujang	-10	Moderate
Jemb. Meritjan	-10	Moderate
Jemb. Kertosono	-10	Moderate
Jemb. Ploso	-16	Moderate
Jemb. Padangan	-10	Moderate

4. Conclusion

The Bengawan Solo River and Brantas River has been polluted from the upstream, this condition are related with the industrial and domestic activities in upper watershed. Upper Bengawan Solo River classified as lightly and moderately polluted, with the most exceeding stream standard parameters were TSS and the least was TDS. Brantas River was classified as lightly and moderately polluted, with the exceeding parameters in order from the most amount to the least were TSS, DO, Cr⁶⁺, TDS, pH.

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