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Water Quality Assessment of Cimanuk River in West Java Using STORET Method

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Abstract. Cimanuk River is the second largest river in West Java after the Citarum River. It is many used as a source of raw water in the Regional Drinking Water Company (PDAM). However, water quality of the Cimanuk River considered polluted. This research aims to assess water quality of the Cimanuk River based on the water quality standards of World Health Organization (WHO), United States Environmental Protection Agency (US EPA), Environmental Quality Standard (EQS), and Regulation of the Governor of West Java (WJP) Class 1. Water sampling stations of Cimanuk River at Sukatani, Boyongbong, Sukamantri, Tomo, Monjot, and Kertasmaya. The STORET method used to assess the water in the Cimanuk River from years 2013 to 2017. Base on ten parameters, this study found that the Cimanuk River is not meet the water quality standards with the value of TSS ($120,93 \pm 99,06$ mg/L), DO ($6,71 \pm 0,96$ mg/L), BOD ($7,43 \pm 3,28$ mg/L), COD ($19,70 \pm 11,77$), NH_3 ($0,43 \pm 0,33$ mg/L), NO_3 ($4,75 \pm 4,19$ mg/L), PO_4 ($0,66 \pm 0,28$ mg/L), and Total Coliform (66600 ± 57415 MPN/100mL). The degradation of the water quality in the Cimanuk River indicated by the decreasing STORET score. STORET score of the Cimanuk River ranging from -36 to -120. The water quality status of the Cimanuk River has heavily polluted. Water pollution in the Cimanuk River is a threat to the sustainability of water resources. Nowadays, the Cimanuk River is not suitable for the drinking water source. However, it is feasible to irrigate agricultural land. Therefore, an increase in collaboration between local communities, regional government, and private sectors is needed to conserve the Cimanuk River.

1. Introduction

Water is one of the natural resources that important function for human life and improves public welfare. The river is one of the water resources that functions as a source of raw water for clean water, irrigation, fisheries, agriculture, recreation, transportation, and conservation. However, rivers in Indonesia are 59% heavily polluted, 27% moderately polluted, 12% slightly polluted and only 1% meet the quality standards [1]. The Cimanuk River is the second largest river from the seven rivers in West Java after the Citarum River. There are the seven rivers that used as water resources in West Java [2]. However, six of the seven rivers in West Java has polluted. Based on Environment Statistics of Indonesia (BPS) in 2017, the Citarum River [2], Ciliwung River [3], Cisadane River, and Citanduy River heavily polluted [1]. Some studies also show the Cilamaya River [2], Cileungsi River [4] heavily polluted.



River water pollution influenced by population growth, land use changes, industrial and domestic waste disposal into rivers [5,6]. Poor river water quality results in poor quality of the environment [5]. Water pollution in the Cimanuk River is a threat to the sustainability of water resources and a weakness to the availability of clean water. If the Cimanuk River polluted, it affects the sustainability of water resources in West Java. Therefore, monitoring of water quality carried out for the management of environmental quality. Water pollution in the river is an important issue that needs serious action from various parties, including academics, government (central and regional), private sectors, local communities, and other stakeholders. So, to address this issue, this research aims to assess the water quality of the Cimanuk River in West Java.

2. Materials and Methods

2.1. Water sampling stations

Water sampling stations of the Cimanuk River were at Sukatani, Bayongbong, Sukamantri, Tomo, Monjot, and Kertasmaya in West Java (Table 1).

Table 1. Water sampling stations of the Cimanuk River

Segment	Sampling stations	Koordinate		Village	Sub-Districts	Districts
		E	S			
Upstream	Sukatani	107° 47.70'	7° 20.99'	Sukatani	Cisurupan	Garut
Upstream	Boyongbong	107° 48.87'	7° 16.31'	Mulyasari	Boyongbong	Garut
Upstream	Sukamantri	107° 54.39'	7° 11.96'	Sukamntri	Garut	Garut
Midstream	Tomo	108° 07.76'	6° 45.86'	Tomo	Tomo	Sumedang
Midstream	Monjot	108° 09.99'	6° 43.90'	Monjot	Kadipaten	Majalengka
Downstream	Kertasmaya	108° 21.00'	6° 31.55'	Pilangsari	Kertasmaya	Indramayu

2.2. Water quality analysis

Water quality analysis of the Cimanuk River obtain by compared the water test results from 6 sample stations and twice a year (from years 2013 to 2017) with the water quality standards of the World Health Organization (WHO) [7,8], United States Environmental Protection Agency (US EPA) [9], Environmental Quality Standards (EQS), and Regulation of the Governor of West Java Number 1/2012 (WJP) Class 1 (Table 2).

Table 2. Water quality standards for river

Parameters	Unit	WHO	US EPA	EQS	WJP
Physical					
Temperature	°C	25	25	25	25
Total Suspended Solid (TSS)	mg/L	50	50	25	50
Chemical					
pH	-	6.6-8.5	5.5-8.5	6.5-8.5	6-9
Dissolves Oxygen (DO)	mg/L	6	8.5	7.5	6
Biological Oxygen Demand (BOD)	mg/L	4	5	1	2
Chemical Oxygen Demand (COD)	mg/L	10	25	10	10
NH ₃	mg/L	0,01	0,2	0,2	0,1
NO ₃	mg/L	50	50	10	10
PO ₄	mg/L	0.05	0.5	0.01	0.2
Biological					

Total Coliform	MPN/100mL	100	5000	1000	1000
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2.3. STORET method

Water quality of the Cimanuk River assessed by STORET method [10,11,12] based on the United States Environmental Protection Agency (US EPA). First, primary data on the water quality of the Cimanuk River collected periodically from 2013 to 2017. Water quality samples from the Cimanuk River taken from 6 sample stations and twice a year periodically. The water test results of the Cimanuk River compared with the water quality standards values (Table 2).

Table 3. STORET score

Total of sample	Value	Parameters		
		Physical	Chemical	Biological
<10	Minimum	-1	-2	-3
	Maximum	-1	-2	-3
	Average	-3	-6	-9
≥10	Minimum	-2	-4	-6
	Maximum	-2	-4	-6
	Average	-6	-12	-18

If the test results meet the water quality standards (the test results < the water quality standards), give a score of 0. However, if the test results do not meet the water quality standards (the test results > the water quality standards), give a score < 0 (Table 3). To assess the water quality of the Cimanuk River, the number of STORET score results compared with the water quality status criteria (Table 4).

Table 4. STORET score and water quality status criteria

Class	STORET score	Status
A	0	Meet quality standards
B	-1 to -10	Slightly polluted
C	-11 to -30	Moderately polluted
D	< -30	Heavily polluted

3. Results and Discussion

The water river pollution and the water quality degradation has been an immense problem to most rivers in Java Island including in West Java [12]. Even, four of the seven rivers in West Java are the national priority river for rehabilitation considering its critical condition [13]. However, the Cimanuk River not included it.

The Cimanuk River is one of the seven rivers in West Java with rainfall average between 1500 to 3000 millimeters per year and 347.697 ha watershed area (Fig 1). The Cimanuk River crosses four districts, namely Garut, Sumedang, Majalengka, and Indramayu District. The Cimanuk watershed divided into three (3) sub-watershed. First, the Cimanuk upstream has an area 145.677 ha in Garut and Sumedang District. Second, the Cimanuk midstream has an area of 114.477 ha in Sumedang and Majalengka District. The last, the Cimanuk downstream has an area of 81.299 ha in Indramayu District.

The Cimanuk River is not one of the government priority rivers for rehabilitation yet, but it would be the regional government priority in West Java Province to conservation it. Over the last five years (from 2013 to 2017), the test result of water quality in the Cimanuk River has been declining dramatically. Water quality of the Cimanuk River shown in Table 5.

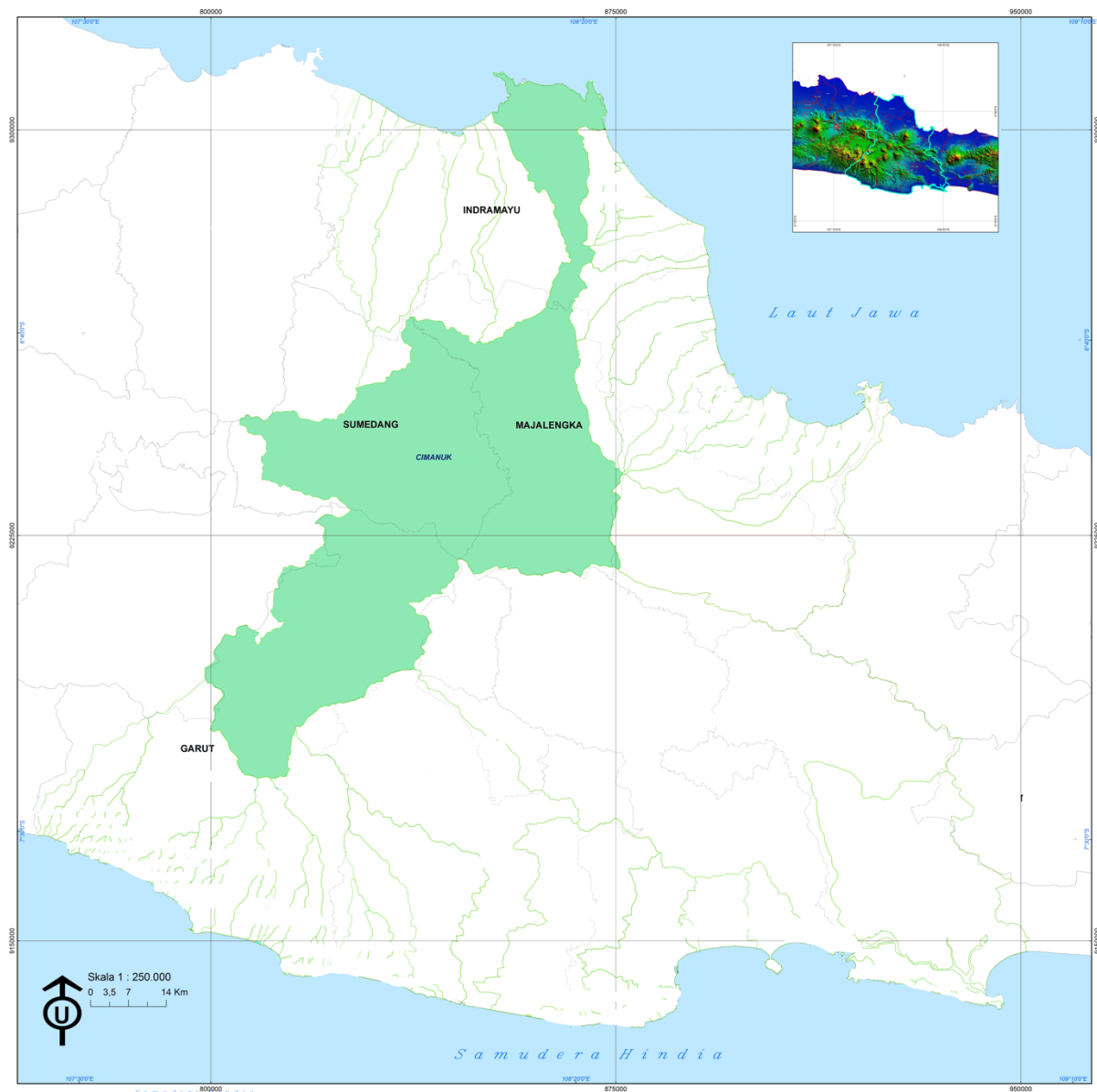


Figure 1. Map of the Cimanuk Watersheed in West Java

Based on Table 5, temperature and pH are the only parameters that meet the water quality standards (Table 2) where the value of Temperature (from 22.4 to 32.1°C) and pH (from 6.94 to 8.66). On the other hand, parameters liked TSS, DO, BOD, COD, NH_3 , NO_3 , PO_4 , and Total coliform does not meet the water quality standards with the following values of TSS (from 19 to 432 mg/L), DO (from 4.9 to 9.2 mg/L), BOD (from 3 to 12 mg/L), COD (from 3 to 42 mg/L), NH_3 (from 0.03 to 1.36 mg/L), NO_3 (from 0.23 to 19.1 mg/L), PO_4 (from 0.12 to 1.25 mg/L), and Total coliform (from 1000 to 180000 MPN/100mL). Water quality degradation in the Cimanuk River according to its physicochemical and biological parameters caused by various activities along there such as industrial activities, agricultural, waste disposal, and cultural practices. River water pollution and water quality degradation influenced by population growth, land use changes, industrial and domestic waste disposal into rivers [5].

Table 5. Water quality of the Cimanuk River

Years	Sampling stations	Parameters									
		Physical				Chemical					Bio
		Temp °C	TSS mg/L	pH mg/L	DO mg/L	BOD mg/L	COD mg/L	NH ₃ mg/L	NO ₃ mg/L	PO ₄ mg/L	Total Coli*
2013	Sukatani	24.1	56	8.05	6.48	9	29	0.67	7.8	0.89	60k
	Bayongbong	26.4	183	7.91	7.48	11	34	1.36	10.9	1.16	120k
	Sukamantri	26.1	111	8.06	6.45	10	34	0.54	9.2	0.85	180k
	Tomo	27.2	95	8.64	6.12	12	35	0.56	10.5	0.56	10k
	Monjot	28.8	33	8.66	6.08	10	42	0.39	9.8	0.66	20k
	Kertasmaya	29.8	74	8.09	5.11	10	37	0.46	9.3	0.75	5k
2014	Sukatani	24.9	80	7.56	6.49	4	6	0.17	2.8	0.41	120k
	Bayongbong	26.8	129	7.68	6.75	5	12	0.18	2.3	0.8	110k
	Sukamantri	29.1	170	7.66	6.11	12	22	0.31	2.1	0.31	140k
	Tomo	27.6	432	7.34	7.6	10	30	0.2	2.2	0.62	160k
	Monjot	27.6	430	7.63	7.37	10	27	0.46	2.4	0.87	170k
	Kertasmaya	28.6	19	7.64	6.7	6	14	0.47	2.5	0.36	80k
2015	Sukatani	23.1	61	7.28	6.86	3	3	0.52	3.6	0.51	1k
	Bayongbong	25.2	143	7.63	7.37	3	4	1.02	3.7	0.38	10k
	Sukamantri	26.8	95	7.63	4.9	3	4	1.25	3.8	0.46	60k
	Tomo	26.6	97	7.8	8.07	4	7	0.22	2.8	0.31	1k
	Monjot	27.8	129	7.93	6.99	4	7	0.03	3.4	0.24	50k
	Kertasmaya	32.1	60	7.78	9.2	6	11	0.04	1.7	0.12	10k
2016	Sukatani	22.4	68	7.38	7.01	3	12	0.13	7.7	0.78	80k
	Bayongbong	24.1	96	7.8	7.72	6	17	0.14	6	1.25	120k
	Sukamantri	25.7	89	7.52	6.53	8	28	0.45	19.1	0.6	140k
	Tomo	29.4	161	8.09	7.44	12	40	0.17	5.1	0.92	8k
	Monjot	30.8	158	7.64	7.32	10	24	0.26	2.4	0.65	60k
	Kertasmaya	30.8	267	7.54	6.51	12	27	0.51	5.6	0.98	60k
2017	Sukatani	24.6	49	7.37	5.63	6	10	0.46	0.58	0.39	32k
	Bayongbong	27.3	75	6.94	5.66	8	15	0.51	0.86	0.79	75k
	Sukamantri	27.5	106	6.96	5.21	12	20	0.74	0.53	0.99	5k
	Tomo	27.3	48	7.58	5.9	4	11	0.42	0.23	0.7	1k
	Monjot	26.5	49	7.42	6.27	5	17	0.03	1.5	0.65	10k
	Kertasmaya	29.5	65	7.41	8.07	5	12	0.08	2	0.87	100k

Sources: Primary data

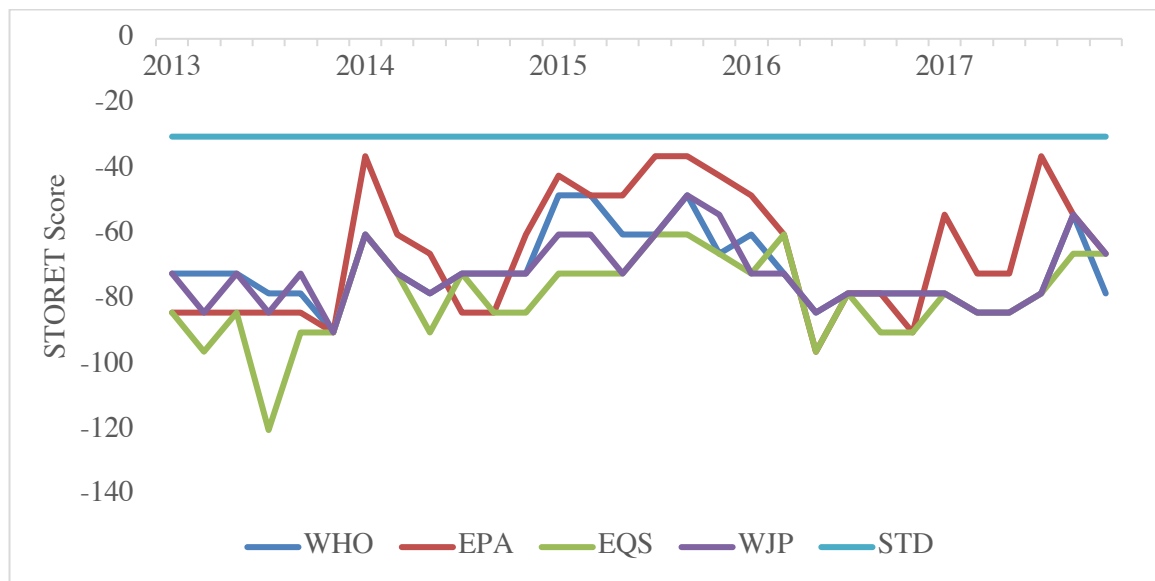


Figure 2. STORET score of the Cimanuk River

Based on Fig 2. STORET score of the Cimanuk River decreased annually from upstream to downstream (from 2013 to 2017). Where STORET score of the Cimanuk River on the WHO (from -48 to -90), US EPA (from -36 to -96), EQS (from -60 to -120), and WJP (from -48 to -90). All STORET score of the Cimanuk River does not meet the standard (< -30) which means all areas heavily polluted. The highest STORET score of the Cimanuk River in Tomo (2013) is -120 and also the lowest STORET score of the Cimanuk river in Sukatani (2014) and Monjot (2015) is -36 which mean heavily polluted. The results of identification, sources of water pollutants in the Cimanuk River come from domestic waste, agriculture, livestock, tofu industry, leather industry, batik industry, traditional and modern market waste along the Cimanuk River.

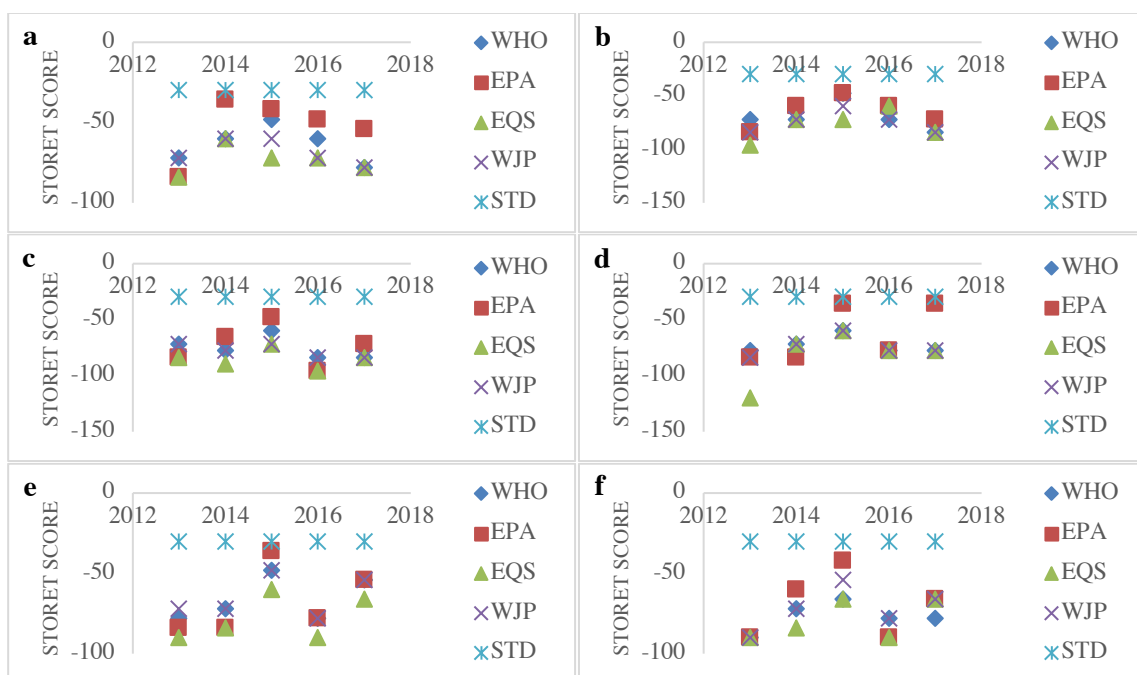


Figure 3. STORET score of the Cimanuk River base on six sampling stations: (a) Sukatani, (b) Bayongbong, (c) Sukamantri, (d) Tomo, (e) Monjot, and (f) Kertasmaya

Base on Fig 3, STORET score from years 2013 to 2017 at Sukatani (from -36 to -84), Bayongbong (from -48 to -96), Sukamantri (from -48 to -96), Tomo (from -36 to -120), Monjot (from -36 to -90), and Kertasmaya (from -42 to -90). Water quality status of the Cimanuk River on six sampling stations has heavily polluted (Table 6). Once the water river heavily polluted, it would be negative impacts on the local water environment, aquatic ecosystem, industrial production, and drinking water sources [14]. Therefore, environmental law enforcement from the government (Environmental Agency) is needed to manage polluters [10].

Table 6. Water quality status of the Cimanuk River

Sampling stations	STORET score				Status
	WHO	US EPA	EQS	WJP	
Sukatani	-63.6±11.7	-52.8±18.7	-73.2±8.9	-68.4±8	Heavily polluted
Boyongbong	-69.6±13.1	-64.8±13.7	-76.8±13.7	-74.4±10	Heavily polluted
Sukamantri	-75.6±10	-73.2±18.2	-85.2±8.9	-78±6	Heavily polluted
Tomo	-73.2±7.8	-63.6±25.3	-81.6±22.7	-74.4±9.1	Heavily polluted
Monjot	-66±14.1	-67.2±21.4	-78±14.1	-64.8±13	Heavily polluted
Kertasmaya	-76.8±8.9	-69.6±20.6	-79.2±12.3	-72±13.4	Heavily polluted

Water pollution in the river influenced by various factors, such as population growth, land use change, uncontrolled of waste disposal into the river, and community activity in the riparian area [15] both from domestic, industry, wastewater and solid waste [12]. Water pollution in the Cimanuk River is a threat to the sustainability of water sources in the future. But in fact, water from the Cimanuk River used as a source of raw water in the five PDAM including Tirta Intan Garut District, Tirta Meda Sumedang District, Tirta Darma Majalengka District, and Tirta Darma Ayu Indramayu District.

Base on this result, water from the Cimanuk River is feasible to use as a source of raw water but more the water treatment needed to produce clean water. Water quality assessment of the Cimanuk River carried out as an effort to manage and control the water quality of the Cimanuk River so that the river can be harnessed and can be used to their usefulness. In this study, an increase in collaboration between regional government (Environmental Agency, Spatial and Urban Planning Agency), local communities, and private sectors needed to conserve and preserve the Cimanuk River.

4. Conclusions

Water from Cimanuk River does not meet the water quality standards of the World Health Organization (WHO), United States Environmental Protection Agency (US EPA), Environmental Quality Standard (EQS), and Regulation of the Governor of West Java (WJP) Class 1. STORET score of the Cimanuk River ranging from -36 to -120. The water quality status of the Cimanuk River has heavily polluted. Nowadays, the Cimanuk River is not suitable for the drinking water source. However, it is feasible to irrigate agricultural land. Therefore, an increase in collaboration between regional government, local communities, and private sectors is needed to conserve and preserve the Cimanuk River.

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