River Water Pollution Indication in The Cimanuk River Downstream, Indramayu District

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Abstract. The Cimanuk River downstream is part of local community activities in the watershed. Uncontrolled waste disposal from these activities will have any negative impact on the water quality of the river and resulting polluted river. This study aims to analyze and assess water pollution in the Cimanuk River downstream. Analyze water quality of the Cimanuk River downstream based on the standard of Government Regulation of the Republic of Indonesia (INA), Regulation of the Governor of West Java (WJP), United States Environmental Protection Agency (US EPA), and Department of Environment (DEO). The pollution index method used to assess the water in the Cimanuk River downstream from years 2015 to 2017. Water sampling site of Cimanuk River downstream was at Kenanga, Bojongsari, Sindang, and Paoman in Indramayu District, West Java Province. This study found that five parameters (Temperature, TSS, BOD, COD, and DO) do not meet the water quality standards with the value of Temperature (30.91±0.68 °C), TSS (62±47.75 mg/L), BOD (21.82±27.42 mg/L), COD (42.29±47.05 mg/L), and DO (4.06±2.45 mg/L). The impact of water pollution causes a decrease in water quality annually. Pollution index value of the Cimanuk River downstream ranging from 1.40 to 17.06. The water quality status of Cimanuk River downstream has been changing from slightly polluted to highly polluted. River water pollution indication due to uncontrollable waste disposal from domestic waste, batik industry, crackers industry, regional public hospital, car wash, traditional and modern market waste along the Cimanuk River downstream. Therefore, a strict environmental law enforcement from the local government to polluters needed to control water pollution in the Cimanuk River downstream in the future.

1. Introduction

Rivers is one of the water resources that important role in environmental sustainability, social welfare and economic growth aspects. However, 59% rivers in Indonesia heavily polluted [1]. The Cimanuk River is one of the rivers that flow in Indramayu District, West Java that receives waste, both from domestic and industrial. The Cimanuk River has been polluted [2,3]. The increase in urban population, changes in land use, construction of settlements, domestic waste disposal into rivers, and industrial development along the Cimanuk River downstream affect the river water quality. Water quality management carries out an effort to control water pollution and maintain of river water functions [4].

The activities of the community and industry along the Cimanuk river have a potential to increase the economy, utilization of the community, but an impact on decreasing the environmental quality.
Moreover, the industry does not have a good wastewater treatment plant (IPAL), so the wastewater from production runoff is discharged directly into the sewer without processing to flow and pollute river water. Community activities continuously carried out without preserving the environment will affect the environmental pollution and decrease the Natural Resources.

Water pollution in the rivers is a threat and weakness to sustainable development goals number six about clean water in the future. Therefore, river water pollution is an important issue needs serious action from various parties, including academics, researchers, government, local communities, industry players, and other stakeholders. So, this study aims to analyze and assess the water quality of the Cimanuk River downstream used pollution index method.

2. Materials and Methods

2.1. Water sampling sites
Water sampling sites of the Cimanuk River downstream were at Kenanga (S 06° 22' 06.8", E 108° 18' 43.13"), Bojongsari (S 06° 21’ 16.8", 33.3", E 108° 18’ 56.0"), Sindang (S 06° 19' 22.0", E 108° 19’ 11.8”) and Paoman (S 06° 19’ 17.9", E 108° 19’ 10.0") in Indramayu District, West Java Province.

2.2. Water quality analysis
The water quality of the Cimanuk River downstream from years 2015 to 2017 obtained by comparing the test results with water quality standards of the Government Regulation of Republic of Indonesia Number 82/2001 on Water Quality and Water Pollution Control (INA) Class 1 [3,5,6,7,8], Regulation of the Governor of West Java Number 1/2012 on Water Pollution Control (WJP) Class 1, United States Environmental Protection Agency (US EPA) [9,10,11], and Department of Environment (DOE) Malaysia [12,13] (Table 1).

| Parameters                        | Unit | INA | WJP | US EPA | DOE |
|-----------------------------------|------|-----|-----|--------|-----|
| Physical                          |      |     |     |        |     |
| Temperature                       | °C   | 25  | 25  | 25     | 25  |
| Total Suspended Solid (TSS)       | mg/L | 50  | 50  | 50     | 25  |
| Chemical                          |      |     |     |        |     |
| pH                                | -    | 6-9 | 6-9 | 5.5-8.5| 6.5-8.5|
| Biochemical Oxygen Demand (BOD)   | mg/L | 2   | 2   | 5      | 1   |
| Chemical Oxygen Demand (COD)      | mg/L | 10  | 10  | 25     | 10  |
| Dissolves Oxygen (DO)             | mg/L | 6   | 6   | 8.5    | 7   |

2.3. Pollution index
Water quality status of Cimanuk River downstream assessed by water pollution index method based on the United States Environmental Protection Agency (US EPA) [4,5,6,14]. Water pollution index calculated by the following formula.

$$PI_j = \sqrt{\frac{(C/L_{ij})^2 + (C/L_{ij})^2}{2}}$$

Where: $PI_j$ is pollution index for a specified water quality purpose ($j$), $L_{ij}$ is standard water quality parameter for each parameter at specified water quality purpose ($j$), $C_i$ is measured water quality parameters, $(C/L_{ij})_{SI}$ is $C/L_{ij}$ maximum, and $(C/L_{ij})_{AV}$ is $C/L_{ij}$ average. $PI_j$ was then compared with the water quality status criteria shown in Table 2.
### Table 2. Pollution index and water quality status criteria

| Pollution index | Water quality status     |
|-----------------|--------------------------|
| Pij ≥ 10.0      | Highly polluted          |
| 5.0 ≤ Pij ≤ 10.0| Moderately polluted      |
| 1.0 ≤ Pij ≤ 5.0 | Slightly polluted        |
| 0 ≤ Pij ≤ 1.0  | Meet quality standards   |

3. Results and Discussion

3.1. General description of the Cimanuk River downstream

Indramayu District lies between (from 107° 52' to 108° 36') East Longitude and (from 6° 15' to 6° 40') South Latitude. Its topography is a plain and a sloped area with the mean inclination of ground from 0 to 2%. This situation effect to drainage. If high rainfall this area will impact to water pond and flood. It's lies alongside the north coastal area of Java Island with means temperature ranging from 22.9°C to 30°C. Whereas, the mean of rainfall during the year 2016 equal to 2,146 mm with a total of the rainy day noted by 142 days.

The Cimanuk River is one of the rivers that flow in Indramayu District. Generally, the Cimanuk watershed divided into three sub-watersheds. One of them is the Cimanuk River downstream has an area of 81.299 ha in Indramayu District. However, water quality of the Cimanuk River downstream decreased as a result of uncontrolled waste disposal along the river that does not meet the carrying capacity [15].

### Table 3. Water quality of the Cimanuk river downstream

| Parameters | 2015 | 2016 | 2017 |
|------------|------|------|------|
|            | Temp. | pH   | BOD  | COD  | DO   |
| Physical   | TSS   |      |      |      |      |
| (1) Kenanga| 31    | 60   | 7.41 | 18.61| 32.08| 2.8  |
| (2) Bojongsari| 31   | 144  | 7.04 | 104.38| 184.74| 1.8  |
| (3) Sindang| 31.5  | 32   | 7.38 | 10.06| 17.5 | 3.2  |
| (4) Paoman | 31.5  | 53   | 7.5  | 31.27| 54   | 2.5  |
| Chemical   |      |      |      |      |      |      |
| (1) Kenanga| 30.6  | 142  | 8.12 | 28.14| 51.92| 2    |
| (2) Bojongsari| 30.4 | 129  | 8.01 | 14.96| 45.47| 2.8  |
| (3) Sindang| 31.6  | 30   | 7.51 | 12.26| 28.5 | 2.5  |
| (4) Paoman | 31.2  | 33   | 7.54 | 18.61| 25.8 | 2    |

3.2. Water quality of the Cimanuk River downstream

Based on Table 3. pH is the only one parameter that meets the water quality standards (Table 1) with a value of pH (from 7.04 to 8.12). On the other hand, five parameters such as Temperature, TSS, BOD, COD, and DO does not meet the water quality standards with the values of Temperature (from 29.3 to 31.7°C), TSS (from 13 to 144 mg/L), BOD (from 4.17 to 104.38 mg/L), COD (from 13.32 to 182.74 mg/L), and DO (from 1.8 to 7.8 mg/L).
Figure 1. Water quality of the Cimanuk river downstream.
(a) Temperature, (b) TSS, (c) pH, (d) BOD, (e) COD, and (f) DO

Based on Fig 1. The highest of Temperature is 31.7 °C in Paoman. The highest concentration of TSS (144 mg/L), BOD (104.38 mg/L) and COD (184.74 mg/L) in Bojongsari. The TSS, BOD, and COD concentrations from upstream to downstream increasing. The concentration of TSS, BOD, and COD high, indicated high water pollution in the rivers. This is due to uncontrollable waste disposal from the domestic and industrial sector along the Cimanuk River downstream. Organic waste is generally in the form of waste that can decompose or be degraded by microorganisms, so that if discharged into the water will increase BOD. Meanwhile, the lowest concentration of DO is 1.8 mg/L in Bojongsari. DO concentrations from upstream to downstream decreasing. Decomposition of organic matter in the river will absorb oxygen in the water so that it will reduce the amount of DO. DO is closely related to BOD and COD because the higher BOD and COD will cause reduced DO in the waters. Base on Fig 1f, DO meet the water quality standard in 2017 at all sampling sites. Fig 1 also showed the parameters TSS,
BOD, COD, and DO does not meet the water quality standards at Bojongsari in 2015. That happened because there had been a lot of fish cracker industry between Kenanga and Bojongsari.

Figure 2. Pollution index value of Cimanuk river downstream

3.3. Status of the Cimanuk River downstream

The decrease in water quality indicates the occurrence of water pollution in the Cimanuk River downstream. The decline in water quality is a result of community activities that ignore the environmental aspects [4]. The results of the water quality analysis used to assess the status of the water quality of the Cimanuk River downstream using the pollution index method (Fig 2).

Based on Fig 2. Pollution index value of Cimanuk River downstream increased annually from Kenanga (as upstream) to Paoman (as downstream) (from 2015 to 2017). Where pollution index value of Cimanuk River base on IDN (from 1.71 to 4.53), WJP (from 1.89 to 5.52), US EPA (from 1.25 to 3.51), and DOE (from 2.42 to 7.39). Specifically, pollution index value base on sampling site at Kenanga (from 2.18 to 6.03), Bojongsari (from 4.73 to 17.06), Sindang (from 1.4 to 3.14), and Paoman (from 2.03 to 6.03).

The highest pollution index value of Cimanuk River downstream is 17.06 in Bojongsari which means this area is highly polluted. The high pollution index value in Bojongsari because there are many fish cracker industries in the village before (Kenanga). Because of many fish cracker industries in Kenanga not yet wastewater treatment plant (IPAL). The absence of IPAL is due to the absence of costs for the procurement and production of batik which is still carried out in traditional ways as well as a lack of awareness from local communities to prevent pollution and maintain the environment [16]. But in fact, water from the Cimanuk River downstream (Bojongsari Dam) still used as a source of raw water in the Regional Drinking Water Company (PDAM) Tirta Darma Ayu in Indramayu District.

The results of identification, sources of water pollutants in the Cimanuk River downstream come from domestic waste, batik industry, fish cracker industries, regional public hospital, car wash, traditional and modern market waste along there (Fig 3). The highest water pollution in the Cimanuk River downstream come from fish cracker industries. Water pollution in the river influenced by various factors, such as population growth, land use change, uncontrolled waste disposal, and community activity in the riparian area both from domestic and industry sectors [17]. River management efforts carried out by increasing law enforcement to industries or actors proven to pollute rivers, improve river quality monitoring, utilize and maintain WWTP facilities [16].
If the water river highly polluted, it would be negative impacts on the local water environment, the carrying capacity of river, aquatic ecosystem, and water resources [18]. If not done, the threat of environmental pollution will continue to occur in the future. Therefore, strict environmental law enforcement from the local government (Environmental Agency, Industrial Agency, Public Works Agency in Indramayu District) to polluters needed to control water pollution in the Cimanuk River downstream in the future. Generally, the Cimanuk River downstream has not suitable for clean water sources. It is feasible for urban water recreation area as an alternative solution.

![Figure 3](image-url)

**Figure 3.** Sources of water pollutants in the Cimanuk River downstream: (a) car wash, (b) fish cracker industry, (c,d) domestic waste, (e) regional public hospital, (f) traditional and modern market waste

4. Conclusions

Water from the Cimanuk River downstream does not meet the water quality standards of the Government Regulation of Republic of Indonesia (INA) class 1, Regulation of the Governor of West Java (WJP) Class 1, United States Environmental Protection Agency (US EPA), and Department of Environment (DOE) Malaysia. Pollution index value of the Cimanuk River downstream ranging from
1.40 to 17.06. The water quality status of Cimanuk River downstream has been changing from slightly polluted to highly polluted. Water pollution in the Cimanuk River downstream indication due to uncontrollable waste disposal from many sectors such as domestic waste, batik industry, fish crackers industry, regional public hospital, car wash, traditional and modern market waste along there. Therefore, strict environmental law enforcement from the local government to polluters needed to control water pollution in the Cimanuk River downstream in the future.

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Acknowledgment
This research supported by Hibah Publikasi Internasional Terindeks untuk Tugas Akhir Mahasiswa (PITTA) 2018 funded by Direktorat Riset & Pengabdian Masyarakat (DRPM) Universitas Indonesia No. 2584/UN2.R3.1/HKP.05.00/2018.