Pollution Index of Cileungsi-Cikeas-Bekasi River

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Abstract. Water quality data of the Cileungsi-Cikeas-Bekasi River (survey results and monitoring data) were analyzed using the Pollution Index (IP) according to the calculation guidelines listed in the Ministry of Environment Decree No. 115 of 2003 concerning Guidelines for Determining Water Quality Status. The goal was to determine the status of the quality or level of river water pollution. The quality standard used in the calculation refers to the class II quality standard based on the West Java Governor Regulation No. 12 of 2013 concerning Water Quality Standards and Water Pollution Control in Cimanuk River, Cilamaya River, and Bekasi River. The IP value of the Cileungsi River shows that the quality status of the Cileungsi River was in moderate pollution, except in the upstream part (good condition). Status of Cikeas River water quality was still in good condition, except in the downstream segment (light pollution). Based on data from the 2019 survey and monitoring of Environmental Agency (DLH) of Bekasi City in the second semester of 2018, the water quality status of Bekasi River is moderate pollution in all segments.

Keywords: downstream; light pollution; moderate pollution; Pollution Index

1. Introduction
The river is a flowing water ecosystem that plays a crucial role in supporting human life. The entry of waste from activities around the waters has the potential to change the conditions of the aquatic environment. This can have negative implications for water quality and aquatic biota, as well as bring harm to the surrounding communities who utilize these aquatic resources [1, 2].

The Cileungsi River is one of the rivers in Bogor Regency, West Java Province which extends from south to north and merges with the Cikeas River to become the Bekasi River. Land use and activities in the upper reaches of the Cileungsi River are quite diverse, such as industry and mining, while the Cikeas River has more settlements. There are many hotels, shopping centers, and hospitals located nearby Bekasi River because Bekasi River passes through urban areas. Excessive use of the land around the watershed has the potential to disrupt the balance of the watershed ecosystem, which has implications for water quality degradation [3, 4].

To assess the health of a water body, it is not enough just to assess the parameters one by one. However, an aggregate value of all water quality parameters is needed, so that the overall water quality conditions can be described [5-8]. Therefore, this study aims to determine the water quality performance of the Cileungsi-Cikeas-Bekasi river.
2. Methodology
Information on water quality of the Cileungsi River, Cikeas River, and Bekasi River was obtained from a field survey in November 2019 (wet season) and monitoring data from DLH (Environmental Agency) Bekasi City in 2018 (semester I/dry season and II/wet season). Observation of several river water quality was carried out in situ and a KAN (ISO 17025) accredited laboratory. Sampling was carried out based on the principle of site representation (upstream, middle, and downstream) for each river [9] (figure 1).

Water quality data were analyzed using the Pollution Index (PI) according to KepMenLH No. 115 [10]. PI calculations were compared with class II quality standards [11]. The results of PI calculations were evaluated using the pollution quality criteria (table 1). Several researchers have applied the pollution index and water quality index to both freshwater and coastal waters [1, 5, 6, 10].

| Pollution Index (PI) Score | Criteria                        |
|---------------------------|---------------------------------|
| 0 ≤ PI ≤ 1.0              | Fulfill quality standard (good) |
| 1.0 < PI ≤ 5.0            | Light Pollution                 |
| 5.0 < PI ≤ 10.0           | Moderate Pollution              |
| PI > 10.0                 | Heavy Pollution                 |

Figure 1. Water quality sampling site.
3. Results and Discussion

Watershed area of Cileungsi–Cikeas–Bekasi River derived from BBWS Ciliwung Cisadane was 140,845.76 ha. Subwatershed determined by contour data (data DEM/Digital Elevation Model). Sub Watershed Cileungsi: 26,340.53 ha, Sub Watershed Cikeas: 10,526.38 ha, and Sub Watershed Bekasi: 2,919.76 ha (figure 2).

![Figure 2. Watershed of Cileungsi-Cikeas-Bekasi River.](image)

3.1. Cileungsi River

PI survey data point out that the quality status of the Cileungsi River is lightly polluted, except in the upstream (good condition) (table 2). PI value has increased from upstream to downstream. Further downstream, more anthropogenic activities affect the Cileungsi River. The PI range for the survey data was 0.80–2.87. Survey water quality data show that in general water quality of the Cileungsi River is still quite good. However, several parameters have exceeded the class II quality standard [11], such as TSS/Total Suspended Solid (middle and downstream), BOD\(_5\)/Biochemical Oxygen Demand (middle), COD/Chemical Oxygen Demand (middle and downstream), and total phosphate (upstream and middle).

DLH (Environmental Agency) Bekasi City monitoring data (semester II) also shows a similar thing, namely that the IP values are not much different and obtained the same status (lightweight). Semester I data showed higher values of 4.97 (middle) and 5.10 (downstream) or belong to light contaminants to moderate contaminants. The monitoring results in the semester I showed that more parameters exceeded the quality standards, namely TSS, BOD\(_5\), COD, DO, Cr\(^{6+}\), Pb, Zn, CN, Cl\(_2\), Fe, Mn, Co, and Ni.
A quite similar river water quality characteristic occurred at the river flowing urban area in Taiwan, the concentration of BOD, ammonia, and total phosphate was the highest among 14 rivers. Besides, heavy metal concentrations exceeded the Taiwan EPA standard namely lead, copper, and manganese [13].

The high level of pollution that occurs in the first semester is understood as an effect of the dry season because the volume of water might be less, so the pollutant concentration increases. A similar phenomenon was encountered by Saraswati et al. [14] in Gadjah Wong River. The water quality indices varied depending on site and monitoring time. The finding of [15], in the dry season, the water quality of the upstream part was normally better than other parts of the river, followed by the middle stream and downstream respectively.

The Cileungsi sub-watershed is much influenced by the existence of an industry which is a strong issue as the main cause of pollution of the Cileungsi River. Besides, in the Cileungsi Sub-watershed, there are also mining activities which are estimated to increase TSS as a result of excavation or land clearing.

### Table 2. Pollution index (PI) of Cileungsi River (2018–2019).

| No | Location                        | Code | Consumption (wet season 2019) | Monitoring Data of DLH Bekasi City (Sem I 2018/dry season) | Monitoring Data of DLH Bekasi City (Sem II 2018/wet season) |
|----|---------------------------------|------|-------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|
|    | Cileungsi River                 |      |                               |                                                           |                                                           |
| 1  | Upstream, Sumur Batu Village    | AP5  | 0.80                          | -                                                         | -                                                         |
| 2  | Middle stream 1, Wika Bridge    | AP6  | 1.04                          | -                                                         | -                                                         |
| 3  | Middle stream 2, Cikuda Bridge  | AP7  | 2.16                          | 4.97*                                                     | 4.40*                                                     |
| 4  | Downstream, Curug Parigi        | AP8  | 2.87                          | 5.10                                                      | 2.75                                                      |

Note:
* Monitoring location in river downstream
- : Fulfill quality standard (good)
- : Light Pollution
- : Moderate Pollution

3.2. Cikeas River

Based on the survey results, the water quality status of the Cikeas River is still quite good, except for the downstream segment (light polluted) (table 3). The upstream and middle segments of the Cikeas River are already in the moderate polluted category, seen from the PI value range of 0.73-0.87. A review of the Cikeas River water quality data from the survey results, it is known that in general, the Cikeas River is still in good condition. However, several parameters have exceeded the class 2 quality standard [12], namely TSS (downstream), total phosphate (middle and downstream), and nitrite (downstream).

Based on monitoring data for semester II 2018, the middle and downstream segments of the Cikeas River have higher PI values, namely 2.21 and 3.58 (light polluted). Even in the first semester of 2018, higher PI scores were observed, namely 6.01 and 6.08 (moderate polluted). More parameters exceeded the quality standard in the first semester of 2018, namely TSS, BOD$_5$, COD, Cr$^{6+}$, Pb, Zn, Cl$_2$, Fe, Mn, and Co.

The relatively greater number of parameters that exceed the quality standard in the first semester is understood as the effect of the dry season, because of the low volume of water in the Cikeas River in that period, so that the concentration of pollutants increases. The Cikeas sub-watershed is also heavily
influenced by various anthropogenic activities such as settlements or housing complexes. Domestic activities, restaurants, and agricultural/plantation activities can contribute to the input of organic matter into the waters thereby increasing TSS, BOD, and nitrite. The domestic waste discharge also still poses a problem in Taiwan [13].

The exceedance of quality standard parameters for TSS, COD, and other metals is thought to be due to the influence of industrial activities such as what happened to the Cileungsi River. However, in the Cikeas Sub-watershed, the influence of industrial activities is not as intensive as in the Cileungsi Sub-watershed, it can be seen from the relatively lower value of the metal parameter monitoring results. The Cikeas sub-watershed is dominated by settlements or housing complexes. Water quality degradation of Cimanuk River started from upstream to downstream was marked by increased pollution index value annually. Cimanuk River pollution index ranged from 1.25–20.31, meaning lightly-heavily polluted [16].

### Table 3. Pollution index of Cikeas River (2018–2019).

| No | Sampling Location                  | Code | Pollution Index (PI) | Monitoring Data of DLH Bekasi City (Sem I/dry season 2018) | Monitoring Data of DLH Bekasi City (Sem II/wet season 2018) |
|----|-----------------------------------|------|----------------------|----------------------------------------------------------|----------------------------------------------------------|
| 1  | Upstream, Cikeas Village          | AP1  | 0.73                 | -                                                        | -                                                        |
| 2  | Middle stream 1, Tapos Village (Depok) | AP2  | 0.87                 | -                                                        | -                                                        |
| 3  | Middle stream 2, Transyogi Bridge | AP3  | 0.82                 | 6.01                                                     | 2.21                                                     |
| 4  | Downstream, Bendung Koja          | AP4  | 1.45                 | 6.08*                                                    | 3.58*                                                    |

Note: * Monitoring location in river downstream (Jatiasih, close to the bridge of Nusaphala Housing Complex)

- Light Pollution
- Moderate Pollution

### 3.3. Bekasi River

Based on data from the 2019 survey and monitoring of DLH (Environmental Agency) for Bekasi City in the second semester of 2018, the water quality status of Bekasi River is lightly polluted in all segments (table 4). The range of IP values obtained from the survey results was 2.11–2.89, while the monitoring data for the second semester of 2018 were 2.35–3.36. Monitoring data in the first semester of 2018 shows a higher value, namely 6.30–6.59 or moderate pollution.

Some parameters have exceeded the class II quality standard [12] in most or even all segments. Parameters that have exceeded the quality standard are TSS (across segments), DO (downstream), total phosphate (upstream and middle), Cu (downstream), and nitrite (downstream). Based on monitoring data, more parameters exceed the quality standards, namely TSS, BOD₅, COD, Cr⁶⁺, Zn, Cl₂, Fe, Mn, Co, and Ni.

The higher levels of pollution in the first semester (based on PI values) such as those found in the Cileungsi and Cikeas Rivers are related to the dry season because the volume of the Cileungsi River water becomes smaller so that the concentration of pollutants increases.

The status of Bekasi River's water quality tends to be worse than the Cileungsi and Cikeas rivers, this is reasonable considering the position of Bekasi River is downstream of the two rivers. Bekasi River has certainly received an accumulated impact from the Cileungsi and Cikeas Rivers. Besides, in the Bekasi River sub-watershed, there are also many anthropogenic activities which are dominated by urban
activities such as restaurants, hotels, shopping centers, hospitals, and housing. The intensity of pollution is much higher in the urban stretches due to untreated or partially treated sewage discharge [17]. By application of water quality index, it was known that Galing River is among the most polluted rivers not only in Kuantan but also in the Peninsular Malaysia [7], Ciambulawung River water quality status and Shanchong river water quality status was also obtained by application of water quality index [18, 19].

| Table 4. Pollution index of Bekasi River (2018–2019). |
|------------------------------------------------------|
| No | Sampling Location | Code | Survey of Bekasi River (wet season 2019) | Monitoring Data of DLH Kota Bekasi (Sem I/dry season 2018) | Monitoring Data of DLH Kota Bekasi (Sem II/wet season 2018) |
|---------------------------------|-----------------|------|-----------------|-----------------|-----------------|
| Bekasi River                    |                 |      |                 |                 |                 |
| 1                               | Upstream, P2C (Joint of Cileungsi-Cikeas River) | AP9  | 2.11            | 6.30            | 2.35            |
| 2                               | Middle stream, Pasar Proyek Bridge               | AP10 | 2.89            | 6.59            | 3.36            |
| 3                               | Downstream, Babelan Village (Before the joint with CBL River) | AP11 | 2.21            | -               | -               |

Note: Light Pollution : Moderate Pollution

Industrial activities are relatively rare in the Bekasi River Sub-watershed. Urban activities can contribute to the input of organic matter into the waters thereby increasing the value of TSS, BOD, total phosphate, and nitrite. The exceedance of quality standards for TSS, COD, and other metals is thought to be a contribution from the flow of the Cileungsi River and Cikeas River which had previously been affected by industrial activities.

4. Conclusion
Field survey (2018) PI of Cileungsi River water quality was good (upstream) and light pollution (middle stream and downstream). DLH (Environmental Agency) monitoring data (2018), light pollution (semester 2/rainy season) - moderate pollution (semester 1/dry season). Field survey (2018) PI of Cikeas River water quality was good (upstream, middle stream) and light pollution (downstream). DLH monitoring data (2018) light pollution (semester 2/rainy season) - moderate pollution (semester 1/dry season). Field survey (2018) PI of Bekasi River water quality was light pollution (upstream, middle stream, and downstream). DLH monitoring data (2018) light pollution (semester 2/rainy season) - moderate pollution (semester 1/dry season).

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