Simple water quality observations in Cikapundung River from upstream to downstream to determine the quality

S A Janetasari*, U Hamidah, Widyarani, N Sintawardani
Research Unit for Clean Technology, Indonesian Institute of Sciences (LIPI)
Jl. Cisitu 21/154D, Bandung 40135, Indonesia

*E-mail: cellyayu@gmail.com

Abstract. Cikapundung River is located through Bandung City, it’s one of stream which flow to Citarum Watershed. Several studies on conservation modelling and planning have been carried out, but there are uncompleted data about water quality of Cikapundung River, therefore study on water quality assessment is required. Data was collected in 26 points starting from upstream in Maribaya and ends in the downstream in Bojongsoang, Bandung City. Parameters that recorded are pH, temperature, conductivity and dissolved oxygen (DO). Result showed that DO levels begin to drop under 5 mg/L in 17000 meters or 17 kilometers from a upstream, the increasing of human activity of this point influenced the level of dissolved oxygen in the surface water, pH ranged from 6.7 to 9.67, while conductivity range about 66 to 410 µS/cm. Sampling locations and land use was determining factors that influenced dissolved oxygen concentration, pH and conductivity values, while climate affects temperatures around the sampling point.

Keywords: Cikapundung River; water quality; assessment; DO; COD

1. Introduction
Citarum River in West Java province, Indonesia, is a vital river that flows along 297 km from Bandung to Jakarta with a population of around 30 million people in the catchment area. From the last 20 years, the water quality in the Citarum River has continued to decline. In 2012 it was reported that 64 % of BOD pollution was caused by domestic waste, while the rest 36 % of contamination came from industrial and agricultural activities. The lack of proper sanitation facilities from the community who live on the banks of the Citarum River and effluent from wastewater treatment plants from industries make the water quality of Citarum River worst. Many industries discharge their waste directly to the river body [1].

In 2018, the President of the Republic of Indonesia issued Presidential Regulation No. 15 of 2018 concerning the Acceleration of Pollution and Damage Control in the Citarum Watershed. President builds a task force to control pollution in the Citarum River Basin, and the water quality should be improved to the decent quality in seven years.

Upstream watershed has the function to maintain the water availability of the central and downstream regions. The damage of upstream watershed can affect the area below. Citarum River has nine sub-river as the primary water sources in the upstream. One of the sub-river which supplied water to Citarum is Cikapundung River. It has 28 km length of the river and flows over 11 sub-districts in three cities and districts of the Great Bandung Area from north to the south part (Bandung City,
Bandung Regency and West Bandung Regency). Cikapundung River has strategies function for drainage, tourism, agricultural irrigation facilities, water power plant and provides raw water for Bandung Municipal Water Supply Company (PDAM) [2]. On the other side, the quality of Cikapundung influenced by people activity who live around Cikapundung riverbank.

On the upstream of Cikapundung live approximately 7,000 stock farmers, who have in average 2-3 cows, and just a few big farmers who have more than 1000 cows. Only half of the stock farmers are using the manure for biogas and the rest disposing of direct to the river body. In the middle stream, the main problem is coming from domestic waste and sanitation. Bandung Government in Spatial Plan 2011 document estimated that in 2015-2020 the population would increase approximately 300,000 people. The report projected rapid growth in population could stimulate the growth of settlement in Cikapundung riverbank. In a developing country, the rapid population growth usually followed by decreasing in proper sanitation facilities [3]. The downstream of Cikapundung is dominated by industrial, and some of the districts categorize as annually flooded areas.

The previous study showed that increased developed and conversion land in Cikapundung River extends the number of impermeable surfaces that reduces infiltration, decreasing supply and rising groundwater runoff [6]. Another research mentioned that the value of deoxygenation rate and the self-purification in Cikapundung River are relatively low, and it is caused mainly by chemical and biological parameters [4]. The decreased river annual flow rate and the high concentration of pollution predict to lower the price of self-purification [5]. Some research on pollutant index in 2018 showed that pollutant index calculation in Cikapundung River in 2016 in the dry session was severely polluted water quality and Cikapundung watershed contaminated with domestic waste in the computation of polluted pollutants potency [7].

The objective of this research was to profiling the quality of Cikapundung River from upstream to downstream and determine the cause of water pollution based on the main problem of each area using secondary data. The research was done with the Cikapundung river bank expeditions in July 2019 in collaboration with a high school mountaineering club from Bandung. Monitoring was performed for parameters that were expected to change: Dissolved oxygen, pH, temperature and Chemical Oxygen Demand. The monitoring result were compared to National Quality Standard of River (PP No.82:2001) [8].

2. Methodology

2.1. Study Location

Water quality samplings were performed in August 2019, from upstream Cikapundung at Bukit Tunggul (06°50.080S, 107°42.456E) until downstream of Cikapundung at Bojongsoang (06°49.806S, 107°41.078E). The sample divided into three areas (upstream, midstream, downstream) which is 11 points at upstream, 9 points at middle and 8 points downstream with the total of the sample were 28 points. Water quality samplings were taken with consideration of the primary land use; samples were made in 5 selected location analysis.

2.2. Sampling and analytical methods

Samples were carried out using a 250 ml water sample in the middle of the flow. The water quality measurements were taken in situ using a water quality checker which measures pH, dissolved oxygen, conductivity and temperature. The sample for chemical oxygen demand (COD) was acidified with nitric acid (HNO₃) 1 M to pH <2. All samples were stored in cold box until being transported to the Research Unit for Clean Technology (LPTB) laboratory. Meanwhile, chemical oxygen demand was analysed using Indonesia National Standard Measurement (SNI 6989:2009) [9].
2.3. Calculation and data analysis
The Cikapundung environmental data display uses secondary data from government documents compared to existing primary data. The water quality index is calculated based on the following Pollution Index (PI) equation (KepMenLH No.115: 2013)

\[
P_I^j = \sqrt{\left(\frac{C_i}{L_{ij}}\right)_M + \left(\frac{C_i}{L_{ij}}\right)_R^2}
\]

where IP_j is Pollution index for j, C_i is parameter of water quality i, L_ij is parameter of water quality i according to National Water Quality Standar for j, M is maximum, and R is average.

(Source: Google map)

Figure 1. Sampling point at Cikapundung River

3. Results and Discussions

3.1. Environment view of Cikapundung River from upstream to downstream

3.1.1. Upstream of Cikapundung River
Upstream of the Cikapundung watershed, located in the northern Bandung, with a catchment area of around 9,401 ha. Upstream of Cikapundung is a protected forest and water spring resources area. One of the problems of upstream is the change in land use. Land-use change that occurred in upstream Cikapundung is significant during the period 1991 to 2014. Based on the previous research, the reduced land as forests, fields, and bushes. Transformation that occurred were forest loss by 0.31 %, shrubs 1.83 %, dry fields 3.27 % [10]. Based on West Java Province data at 2014, total area of Cikapundung sub-watershed is 14,000 Ha, dominated with built-up land about 36.41 % or 5,444 Ha while forest area only 10 % and 16 % or 2,523 ha are used for agriculture [11].

Another severe problem that occurs upstream is the disposal of cow dung directly into the river body. Upstream of the Cikapundung river is located in West Bandung Regency which is famous as a centre for animal husbandry, according to Agriculture and Food Service data, there are 21 thousand cattle in the Regency. One of the regencies known as livestock centers is Kampung Areng - Cibodas with a total of around 200 cows. The dairy farming business in Areng Village is a community dairy
cow business with 1-4 cattle ownership per breeder [12]. Out of 160 households, less than 50 % use manure as biogas. If per cow produces 25 kg of cow dung per day, the estimated amount of manure entering the Cikapundung river body is around 2500 kg per day, the source of this pollution will affect the water quality of Cikapundung, especially the pH value.

| Commodity | Total |
|-----------|-------|
| Cattle    | 238   |
| Dairy cow | 20,805|
| Sheep     | 17,918|
| Goat      | 1,048 |
| Horse     | 526   |

Source: Agriculture and Food Service of Bandung Barat Regency.

3.1.2. Middle-stream of Cikapundung River

Bandung is a city that has a high rate of waste increase. The number of buildings in downtown Bandung is increasing, around 73.5 % of Bandung is built-up land. The change in land use to housing is followed by an increase in the amount of waste produced.

![Figure 2. Solid waste point in Cikapundung](Source: Citarum.org)
Based on the Long Term Development Plan document of Bandung City for 2011-2031 which shown in Table 2, it is estimated that within 14 years of period, the population of Bandung increased by more than one million people [3]. The increasing population followed by the increasing the waste amount as well. From Table 2, it is known that the total of household waste in 2020 increased by up to 1 million liters per day from the year 2015, with a total of solid waste from a various sources about 12 million liters per day. The Bandung Sanitation and Landscaping Service stated that garbage service in Bandung is still 54 % or there 5 million liters water that has not been handled every day. The amount of garbage in the river body can increase the organic matter and decrease dissolved oxygen (DO) value.

Table 2. The prediction of garbage in Bandung City during 2009-2020.

| Year | Total Population | Amount of Garbage (L/day) |
|------|------------------|---------------------------|
|      |                  | Household | Market | Street | Commercial | Institution | Industry | Total   |
| 2006 | 2,296,848        | 5,742,120 | 1,708,496 | 502,445 | 545,226 | 255,774 | 122,881 | 8,876,941 |
| 2009 | 2,761,208        | 6,903,020 | 1,813,069 | 533,199 | 578,598 | 271,429 | 130,402 | 10,229,717 |
| 2010 | 2,824,642        | 7,061,605 | 1,849,331 | 543,863 | 590,170 | 276,858 | 133,010 | 10,454,836 |
| 2015 | 3,141,812        | 7,854,530 | 2,041,811 | 600,469 | 651,595 | 305,673 | 146,854 | 11,600,931 |
| 2020 | 3,458,982        | 8,647,455 | 2,254,324 | 662,966 | 719,414 | 337,488 | 162,138 | 12,783,785 |

3.1.3. Downstream of Cikapundung River

The downstream area of Cikapundung is dominated by the housing and textile industry. Based on data from Bandung Regency there are 345 industries around Cikapundung and Citarum. Some of them use wastewater treatment plants to treat their wastewater, but the rest are discharged directly into water bodies. Previous studies mentioned that textile wastewater has a pH of around 12 or very basic, and COD concentrations around 200-250 mg/L [15]. One of the sub-districts located in the Cikapundung watershed is Bojongsoang. Geographically, Bojongsoang Subdistrict consists of: Agricultural Areas, Rice Fields and Fishponds, Residential and Residential Areas, Industrial Areas, Trade and Service Areas, Dirty Water Management Installation Areas of PDAM Kota Bandung.

Bojongsoang District has a Municipal Wastewater Treatment Plant (IPAL) which serves about ± 56,298 families. Bojongsoang's main wastewater treatment plant (WWTP) design consisted of physical processing including equipment to separate waste and sand, biological processing including a series of anaerobic, facultative and maturation ponds [16].

Bojongsoang is also known as one of the sub-districts in the flood-prone category. As with previous research on flood-prone areas in Bandung Regency, it is stated that the estimated flood-prone areas in the Bandung basin are 11,886.87 ha. Most of the flood-prone areas are in the Districts of Rancacakek, Bojongsoang, Solokan Jeruk, Ciparay, Cileunyi, Bale Endah and Cikancung. This area is geographically or naturally an area of water habitat [17], changes in land use affect the increase in runoff flowing into rivers, the magnitude of this runoff that causes downstream Cikapundung cannot hold water and become vulnerable to flood disasters.

3.2. Water quality measurement

3.2.1. Dissolved oxygen and chemical oxygen demand

Dissolved oxygen (DO) is one of the critical parameters used to determine the quality of water. From the results of in situ measurements, based on the distance between 0 – 1,500 meters from the upstream the DO value ranged from 6-9 mg/L. The high DO concentration in the upstream is influenced by
water flow and discharge, temperature, topography. DO levels begin to drop under 5 mg/L in 17000 meters or 17 kilometers from a distance, the increasing of human activity of this point influenced the level of dissolved oxygen in the surface water. The DO concentrations in 20,000 to 26,000 meters from the first sampling point continuously dropped between 4.51-1.48 mg/L. Based on the analysis results; there were 5 points that did not meet of National Water Quality Standards.

Tabel 3. Water Quality in Upstream to Downstream of Cikapundung River

| Sample Point             | pH  | National Water Quality Standard PP 82/2001 | COND uS/cm | PP No.20 /1990 | TEMP | National Water Quality Standard PP 82/2001 |
|--------------------------|-----|------------------------------------------|------------|----------------|------|------------------------------------------|
| Upstream - Maribaya      | 8.09 |                                          | 82         |                | 21.2 |                                         |
| Batu Loceng Village      | 7.56 |                                          | 92         |                | 21.1 |                                         |
| Before The Lodge         | 6.70 |                                          | 98         |                | 21.7 |                                         |
| After The Lodge          | 7.15 |                                          | 66         |                | 21.9 |                                         |
| Kampung Areng            | 8.94 |                                          | 115        |                | 20.2 |                                         |
| Before Tebing Keraton    | 9.67 |                                          | 90         |                | 22.2 |                                         |
| Curug Ciomas             | 8.00 |                                          | 222        |                | 21.8 |                                         |
| Bridge between Curug     | 8.40 |                                          | 213        |                | 22.0 |                                         |
| Curug Lalai              | 8.21 |                                          | 219        |                | 23.0 |                                         |
| Batu Batik               | 8.45 |                                          | 206        |                | 23.0 |                                         |
| Deer Conservation TAHURA | 8.70 |                                          | 202        |                | 23.1 |                                         |
| PLTA Dago Bengkok        | 8.29 |                                          | 140        |                | 21.7 |                                         |
| Bridge Dago Bengkok      | 8.30 |                                          | 194        |                | 22.3 |                                         |
| Curug Dago               | 9.10 | 6-9                                      | 212        | 2250 uS/cm     | 24.4 | Deviation 3                             |
| PLTA Dago Pojok          | 8.19 |                                          | 192        |                | 22.4 |                                         |
| DAM BBWS                 | 7.70 |                                          | 238        |                | 25.2 |                                         |
| Bandung Zoo              | 8.00 |                                          | 292        |                | 24.3 |                                         |
| Unisba                   | 7.59 |                                          | 291        |                | 23.6 |                                         |
| Asia Afrika              | 7.55 |                                          | 306        |                | 23.7 |                                         |
| Lengkong                 | 7.91 |                                          | 245        |                | 22.5 |                                         |
| Ancol Market             | 7.48 |                                          | 291        |                | 22.8 |                                         |
| Pasir Luyu               | 7.64 |                                          | 350        |                | 23.2 |                                         |
| Mengger                  | 7.88 |                                          | 266        |                | 23.9 |                                         |
| Batu Nunggal             | 7.92 |                                          | 384        |                | 25.3 |                                         |
| Mengger Hilir            | 7.28 |                                          | 395        |                | 25.6 |                                         |
| Desa Lamajang            | 7.48 |                                          | 410        |                | 26.8 |                                         |
| PDAM Tirta Raharja       | 7.35 |                                          | 327        |                | 27.3 |                                         |
| Cikapundung- Citarum     | 7.16 |                                          | 412        |                | 27.3 |                                         |
Figure 3. DO degradation based on the distance from upstream

The downstream of the Cikapundung area has a BOD value of 28 mg/L; this BOD value is above the quality standard that is 12 mg/L. The high BOD value is caused by industrial waste disposal, and also the accumulation of pollution from upstream and middle of Cikapundung [7], based on the results of the COD analysis, the COD value in downstream of Cikapundung is 1431 mg/L at the Lamajang and 1226 mg/L at the meeting point of Cikapundung and Citarum, exceeds the National Quality Standard that is 100 mg/L.

Based on the results of chemical oxygen demand analysis, there was a significant increase in upstream sampling points compared to sampling points in the middle and downstream (Figure 4). Chemical oxygen demand (COD) is an indicator of water quality that shows the capacity of water that uses oxygen to decompose compounds dissolved organics and oxidizes inorganic compounds in water. The high content of COD can be caused by the degradation of organic and inorganic materials from community activities and the waste generated by industries that are not appropriately treated [7].

Figure 4. COD Total Concentration in 5 Sample Point
The previous study mentioned that the quality of Cikapundung was various from somewhat polluted at the dry season and slightly polluted at the rainy season [7]. This is similar to the calculation of the water quality index based on COD values at 5 sample points in Cikapundung. From the calculation obtained that the water quality index value by the Pollution Index (PI) method is 8.6 or relatively polluted.

3.2.2. pH and temperature
The pH value along the Cikapundung River is quite stable, from the measurement results obtained pH range between 9.67 and 6.70. From the data analysis, known that the highest pH is in sample point 6 (Figure 3), which is the point near Kampung Areng. Kampung Areng known as one of dairy cows husbandry at Bandung Barat Regency, some Kampung Areng villagers use processed cow dung as biogas, fertilizer and also for raising worms. Untreated cow manure and compost disposal directly into the river will be mixed with microorganisms that degrade organic matter, degradation of protein and organic nitrogen into ammonium can raise the pH to a base [13].

Based on the measurement results, the temperature from upstream to downstream is between 20.2 and 27.3 °C. There is a 7 °C difference between the lowest temperature in the upstream and the highest temperature in the downstream point. River water temperature is influenced by seasonality, latitude, altitude, time of day, air circulation, cloud cover, and flow and depth of water bodies [14]

3.2.3. Conductivity
Conductivity is one of the parameters to measure the water quality; conductivity value showed the mineral and salt-containing in the water; this value usually related to the Total Dissolved Solid amount (TDS). Dissolved solid (DS), on the other hand, includes those materials dissolved in the water, such as bicarbonate, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These ions are essential in sustaining aquatic life [18]. Conductivity is one of the parameters to measure the water quality; conductivity value showed the mineral and salt-containing in the water; this value usually related to TDS.

Electrical conductivity values range between 66 and 412 µS/cm, although the conductivity is still acceptable of the National Standard of Quality Water, the amount of conductivity increasing from upstream to downstream as shown in Figure 5 that the trend line of values is risen up from upstream to the downstream. At the sample point of downstream of Cikapundung, the conductivity value increased due to the presence of industrial waste discharges that enter the river body.

4. Conclusion
Cikapundung River from upstream to downstream have a various water quality according to land use and people activity. The upstream dominated with conservation area and the problem is pollution from agriculture and farm. Middle stream dominated with housing and domestic waste while downstream dominated with industrial and flood prone area. From 28 sample result shows the value of dissolved oxygen DO levels begin to drop under 5 mg/L in 17000 meters or 17 km from a upstream and in 20,000 to 26,000 meters from the first sampling point continuously dropped between 4.51-1.48 mg/L. pH ranged from 6.7 to 9.67 , while conductivity range about 66-410 µS/cm. From the calculation of pollution Index, the Cikapundung is categorized with fairly polluted with some sample point of Dissolved oxygen, Chemical oxygen demand and pH value did not fulfill the National Standard of Water Quality. Regarding to calculation of the water quality index based on COD values at 5 sample points in Cikapundung, the water quality index value by the Pollution Index (PI) method is 8.6 or fairly polluted.
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References
[1] DHV, Deltares, MLD, 2012. Water Quality in Citarum River Report November 2012. Kementerian Pekerjaan Umum dan Perumahan Rakyat.
[2] Badan Perencanaan Pembangunan Nasional. 2015. Gambaran Umum Sungai Cikapundung. URL. http://citarum.bappenas.go.id/info-citarum/berita-artikel/1174-gambaran-umum-sungai-cikapundung.html, (accessed. 29.09.2019)
[3] Pemerintah Kota Bandung. 2011. Rencana Tata Ruang Wilayah Kota Bandung Tahun 2011-2031. Bandung: Tim Penyusun
[4] Yonik Meilawati Yustiani, Mia Nurkanti N S and A N. 2018. Influencing Parameter Of Self Purification Process In The Urban Area Of Cikapundung River, Indonesia. Int. J. Geomate
[5] Hendriarianti E and Karanaisingroem N 2015 Deoxygenation Rate of Carbon in Upstream Brantas River in the City of Malang. J. Appl. Environ. Biol. Sci. 5 36–41
[6] Wibowo M 2005 Analisis pengaruh perubahan penggunaan lahan terhadap debit sungai. J. Tek. Lingkung. 6 283–90
[7] Rahayu Y, Juwana I, Marganingrum D and Lingkungan J T 2018 Kajian Perhitungan Beban Pencemaran Air Sungai Di Daerah Aliran Sungai (DAS) Cikapundung dari Sektor Domestik J. Rekayasa Hijau 2 61–71
[8] Pemerintah Republik Indononesia.2001. Peraturan Pemerintah Republik Indonesia No.82.2001: Tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran. Jakarta: Sekretariat Negara
[9] Standar Nasional Indonesia. 2009. Air dan Limbah – Bagian 2: Cara Uji Kebutuhan Oksigen Kimiawi (Chemical Oxygen Demand) dengan Refluks Tertutup secara Spektrofotometri. Jakarta: SNI 6989.2.2009
[10] Badan Pusat Statistik.2018. Kabupaten Bandung Barat dalam angka 2018. Bandung: BPS
[11] Pemerintah Provinsi Jawa Barat.2018. Pemprov Jabar Serius Tangani Citarum. URL.https://jabarpov.go.id. Accessed : 1st September 2019
[12] Wulan, Erlina Risika Windu.2015. Dampak Ekonomi Sosial dan Lingkungan Pemanfaatan Limbah Ternak di Kampung Areng Desa Cibodas Kecamatan Lembang Kabupaten Bandung. Skripsi. Institut Pertanian Bogor
[13] Irfan, Rasdiansyah, M. M. (2017). Quality Of Bokasi Made From Various Livestock Manures. Jurnal Teknologi Dan Industri Pertanian Indonesia, 9.
[14] Effendi,H. 2003. Telaah Kualitas Air bagi Pengelolaan Sumberdaya dan Lingkungan Perairan. Kanisius. Yogyakarta. Hal: 278
[15] Pratiwi Y 2010 Penentuan Tingkat Pencemaran Limbah Industri Tekstil Berdasarkan Nutrition Value Coefficient Bioindikator. J. Teknol. 129–37
[16] Mangunwardoyo W and Mufti P 2013 Bioremediation Of Effluent Wastewater Treatment Plant Bojongsoang Bandung Indonesia Using Consorsium Aquatic Plants Bioremediation Of Effluent Wastewater Treatment Plant Bojongsoang Bandung Indonesia Using Consorsium. IJRRAS
[17] Yulianto F, Sulma S and Khomarudin M R 2018 Observing the Inundated Area using Landsat-8 Multitemporal Images and Determination of Flood-Prone Area in Bandung Basin Int. J. Remote Sens. Earth Sci. 15 131–40
[18] White P G 2013 Mitigating aquaculture impact in the Philippines