Analysis of water pollution using the STORET method in the Upper Citarum Watershed

Atiti S. U. Mudjiardjo\(^1\), Setyo S. Moersidik\(^1\)* and Linda Darmajanti\(^1\)

\(^1\)School of Environmental Science, Universitas Indonesia, Central Jakarta, 10430, Indonesia

*ssarwanto@eng.ui.ac.id

Abstract. River water pollution in the Upper Citarum Watershed is increasingly being reported, research shows that the quality of river water has decreased drastically where along the 127 km or 47.1% of the Citarum river has been heavily polluted, it is estimated that every day the Citarum River accommodates 280 tons of waste. There are 31 water quality monitoring stations in the Upper Citarum Watershed: Cisanti Springs, Situ Cisanti, Bd. Wangisagara, Majalaya, Cengkrong, Solokan Jeruk, Sapan, Peundeuy, Komp. Radio, Cisirung, Pataruman, Kamasan, Dayeuh Kolot, Cukang Genteng, Sadu, Nanjung, Citarum Kp. Pariang Pojok, Kertajaya, Cb. Bungin Leuwigajah, Teras Cikapundung, Sukapada, Cikapundung Asia-Africa, Cinambo, Ciwastra, Jatiroke, Cikijing, Cimanggung, and Sindang Pakuon. Based on data analysis obtained from BBWS Citarum, data from 2011-2019 are obtained. This research aims to determine water quality status using STORET method in the Upper Citarum Watershed as indicator of environment pollution. This research method is quantitative, using the STORET method. The results show that the water quality conditions are heavily polluted, so it is necessary to make various efforts to tackle the pollution that occurs regularly, one of the ways is revitalization.

1. Introduction
The Citarum River is a river that is widely used for community life along its watershed. The Citarum River's use includes agriculture, animal husbandry, hydropower, industry, and household needs. The upstream of this river is in the Bandung Regency area [1]. Water pollution in the Citarum watershed, especially the upstream area, is increasingly being reported; research shows that the quality of river water has decreased drastically where 127 km or 47.1% of the Citarum river has been heavily polluted, it is estimated that every day the Citarum River accommodates 280 tons of waste [2].

River pollution is still a problem in many countries, especially in developing countries, including Indonesia. Limited infrastructure and human resources, along with a weak monitoring and law enforcement system, have caused river pollution levels to get higher [3]. A river is said to be polluted if the water quality is not following its purpose. According to the river class, this water quality is based on water quality standards based on Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control [4].

Restoration of water quality as part of controlling water resources is carried out to ensure that water quality is following the quality standards for its designation. Controlling pollutants originating from various pollutant sources that enter the water source is carried out by considering the water source’s
intrinsic conditions and the determined water quality standards. River pollution can occur directly from
the outfalls of sewerage or industrial waste as point sources and runoff from agriculture or urban areas
as non-point sources [5].

One way to control an ecosystem's pollution can be done by monitoring water quality for a certain
period so that the water quality status is known [6]. If there is pollution, immediately prevent and control
it according to the level of pollution [7]. The STORET method is a method to determine the water quality
status, which is commonly used. In principle, this method compares the water quality data with the water
quality standards following their designation [8]. The results of the comparison of each of these
parameters are given a value (scoring) so that the value (score) of all parameters becomes an index that
states the level of water quality. Quality standards used are quality standards for the designation of
aquatic biota (fisheries). If, based on the baseline study, it is known that a certain parameter exceeds the
quality standard but is a local natural condition, then the value of the natural condition is used as a
reference. The assessment of water quality levels using the STORET method approach is not determined
by how many parameters and parameters should be used. As long as the existing water quality
parameters can be compared with the quality standard (there is a quality standard), the quality level
index can be determined using the STORET method [8,9].

The Citarum River contributes greatly to the economic activities of the people of Bandung Regency.
Various kinds of activities or interests exist in the Citarum River area, such as the majority of the people
in the Upper Citarum Watershed utilize the land for agricultural activities, as well as tourism and
industrial activities. It is feared that the high human activity in the Upper Citarum Watershed will impact
the pollution of the bay water quality conditions. Therefore, to ensure the Citarum River ecosystem's
sustainable function, it is necessary to monitor the status of its water quality. This study aims to
determine water quality status using the STORET system in the upper Citarum watershed as an
indicator of environmental pollution.

2. Method

Geographically, the Upper Citarum Watershed is located between 107°30 ' - 108° EL and 6°43'-7°15'
SL and is bordered by Purwakarta Regency and Subang Regency in the north, Bandung Regency in the
west on the west, Sumedang and Garut Regencies in the east, and borders on the south. Cianjur and
Garut regencies.

Geomorphologically, the Bandung Basin covers an area of approximately 181,027 hectares [10, 11].
The upstream Citarum watershed generally has varying altitudes from plains to hills (650 - 1800 masl)
with rainfall ranging from 1000 - 3500 mm/year. The following is a map of water quality monitoring
stations' location in the Upper Citarum Watershed (Figure 1).

This research focuses on the Upper Citarum Watershed. The method used is to conduct a literature
study on the quality of citarum water based on monitoring records at 21 water quality monitoring stations
spread across all upstream areas of the Citarum watershed (see Figure 1) for statistical analysis using
the STORET method. The STORET analysis method stands for Storage and Retrieval and is a method
developed by the Environmental Protection Agency (EPA-USA) as an effort to control water quality
from both physical, biological, and physical aspects of water. The statistical data from the literature
study on the quality of citarum water used is time-series data between 2011 and 2019 published by the
Citarum River Basin Center (Balai Besar Sungai Wilayah/ BBWS) as the agency in charge of the
management of Citarum river water.

The assessment parameters for the STORET method are physics, chemistry, and biology aspects.
The data source recorded 20 water parameters, which include: 4 parameters related to physical factors,
including temperature, turbidity, color, and suspended solids (SS). SS value is solid suspended in water
in organic/inorganic materials that affect water turbidity. Sixteen parameters related to chemical factors
include alkalinity, free CO2, dissolved oxygen (DO) or solubility of oxygen, nitrite, ammonia, copper,
phosphate, sulfide, iron, hexavalent chromium, manganese, zinc, lead, chemical oxygen demand (COD),
and detergent. DO value is the amount of dissolved oxygen in the water. Water with less oxygen makes
the life of microorganisms not last long and will cause odors. Calculate the score for each minimum,
maximum and average value of the water parameter with the STORET-USEPA standard as a reference: For all minimum, maximum and average values per 10 water parameter data (Step 2) that are still within the minimum value limit -Maximum reference (Step 1) will be given a score of 0.

Figure 1. Distribution Map of the Upper Water Quality Monitoring Stations of the Citarum Watershed.

More specifically, the STORET method classifies water quality into 4 classes, namely: a) Class A: very good / meet quality standards (score = 0); b) Class B: good / lightly polluted (score = -1 to -10); c) Class C: moderate / medium polluted (score = -11 to -30), and; d. Class D: poor / heavily polluted (score ≥ -31). Technically, the analysis of water quality status using the STORET method is carried out in the following stages: 1) Collecting water quality and water discharge periodically to form data from time to time (time series data); 2) Compare the measurement data of each water parameter with the quality standard value according to the water class; 3) If the measurement results meet the water quality standard (measurement results < quality standard) then a score of 0 is given; 4) If the measurement results do not meet the water quality standard (measurement results > quality standard) [8].

3. Results and discussion

3.1. Water quality monitoring station
The Citarum River is still categorized as a heavily polluted river [12]. A heavily polluted river indicates poor river water quality. The decline in the quality of the Citarum River water until 2019 was caused by high pollutants entering the river, which could come from human activities in the form of agricultural, livestock, fishery, industrial and domestic activities.
Figure 2. Water Quality Monitoring Station Score Graph in Cisanti Water Springs, Bd. Wangisagara, Cengkrok, Situ Cisanti, and Majalaya 2011-2019.

Figure 3. Water Quality Monitoring Station Score Graph in Solokan Jeruk, Peundeuy, Sindang Pakuin, Sapan, and Cimanggung 2011-2019

Figure 4. Water Quality Monitoring Station Score Graph in Cikijing, Jatiroke, Ciwastra, Cikuda, and Sukapada 2011-2019.
Figure 5. Water Quality Monitoring Station Score Graph in Cinambo, Cikapundung Asia-Afrika, Komp. Radio, Teras Cikapundung, Pasirluyu 2011-2019.

Figure 6. Water Quality Monitoring Station Score Graph in Cisurung, Kamasan, Jb. Cilampeni, Pataruman, Dayeuh Kolot 2011-2019.

Figure 7. Water Quality Monitoring Station Score Graph in Cukang Genteng, Kertajaya, Leuwigajah, Sadu, Cimahi Cihujung and Nanjung 2011-2019. Source: 2020 Storet Calculation Results.
There are 31 water quality monitoring stations in the Upper Citarum Watershed, namely: Cisanti Springs, Situ Cisanti, Bd. Wangisagara, Majalaya, Cengkrong, Solokan Jeruk, Sapan, Peundeuy, Komp. Radio, Cisirung, Pataruman, Kamasan, Dayeuh Kolot, Jb. Citampeni, Cukang Genteng, Sadu, Nanjung, Citarum Kp. Pariang Pojok, Kertajaya, Cb. Bungin Leuwigajah, Cimahi Cihujung, Teras Cikapundung, Sukapada, Cikapundung Asia-Africa, Cinambo, Ciwastra, Jatiroke, Cikuda, Cikijing, Cimanggu, and Sindang Pakuon. Based on data analysis obtained from [13], data from 2011 to 2019 were obtained. From the data in Figure 2, 3, 4, 5, 6, and 7, there are several changes in the level of contamination which were assessed by the STORET method, here are the results of the analysis of the changes that exist each year:

- In the Cisanti Spring area, in 2011-2014, the water quality conditions met the quality standards. Then the status of water quality from 2015 to 2016 deteriorated to become heavily polluted → class D category or very polluted, and the condition of the water quality status improved in 2017 to become lightly polluted. Conditions worsened again to become heavily polluted in 2018 and 2019.
- 30 of the 31 locations of water quality monitoring stations are heavily polluted in 2019 (except for the Situ Cisanti area, the water quality condition is moderate).
- The factors causing water pollution include population density. Population density can affect the river and situ environmental pollution. This is related to the level of awareness of the population in maintaining a healthy and clean environment. Domestic waste, which can be in the form of household water disposal, solids in the form of garbage disposed of into rivers, bathroom washing water, and feces, will affect the levels of BOD, COD, and E. Coli bacteria in the river. Meanwhile, both organic and inorganic industrial waste will also affect surface water quality. Domestic, industrial, and agricultural waste will influence the existence of the river’s environmental components. If this influence has changed the waters’ condition so that they cannot be properly reused, the waters are said to be polluted. The denser the population of an environment, the more waste that must be controlled.

3.2. Efforts to improve water quality
Because all water quality monitoring stations are heavily polluted, it is necessary to make various efforts to tackle the pollution that occurs early, one of which is by managing water resources. Pollution degrades the natural environment [14]. States that water resources management is very important so that it can be used sustainably with the desired quality level [15]. One of the management steps taken is monitoring and interpreting water quality data, including the quality of physics, chemistry, and biology. One of the efforts to manage water resources is the Citarum River Revitalization Program. The Citarum River Revitalization Program is an effort to improve water quality. This was confirmed on February 22, 2018, by planting trees in the upstream area of the Citarum river in Tarumajaya Village, Bandung Regency, and the President released the Citarum Harum program and on March 14, 2018, the issuance of Presidential Regulation of the Republic of Indonesia Number 15 of 2018 concerning accelerated control of pollution and damage. The Citarum Watershed is targeted for this program to be achieved in the next five years [16].

One of the problems that occurred in 2018 after a year of the revitalization program was the handling of Coliform parameters, which increased rapidly compared to 2017 (with the Coliform water quality value of -3). The cause of an increase in Coliform can be caused by human and animal waste flowing in the river flow with too much capacity so that it can contaminate river water. From the results of field observations, there is clear evidence of the revitalization process that has been carried out by the Government in revitalizing the Citarum river, namely that there have been reduced piles of garbage in the upstream Citarum river, and dredging has been carried out in areas prone to flooding. The implementation of these activities can be carried out by anyone from three primary elements, namely, the government, the private sector, and the community [17].
4. Conclusion
The trend of water quality in the Upper Citarum Watershed (all points of the monitoring area) carried out from 2011 to 2019 using the STORET method has fluctuated every year but is still dominated by moderate and heavy levels of pollution. Scoring results using the STORET method at 30 of the 31 locations of water quality monitoring stations in heavily polluted conditions (class D) in 2019 (except for the Situ Cisanti area, the water quality condition is moderate or class C). Because all water quality monitoring stations are heavily polluted, it is necessary to make various efforts to tackle the pollution that occurs early, one of which is water resources management. In addition, efforts to improve water quality are carried out through the Citarum River Revitalization Program. There is a need to enforce stricter regulations for factory offenders who still dispose of waste directly into the river stream without prior treatment. Conducting outreach and inviting residents around the riverbanks to protect the river from dumping garbage directly into the river so that the revitalization process runs well. It is necessary to do further research to see the improvement trend after the Government's Revitalization program, which targets the next five years. Suggestions for further research, an in-depth analysis of the entire Citarum area is needed.

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