Spatial distribution of water quality in Belawan River, North Sumatra

A Mirandha¹, Irvan²* and H Wahyuningsih³

¹ Master Program in Department of Natural Resources and Environmental Management, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
² Department of Chemical Engineering, Faculty of Engineering, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
³ Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

Abstract. Belawan river is one of the rivers in North Sumatera Province. Belawan river which crosses Deli Serdang District and Medan City is used for the activities of plantation, agriculture, livestock, sand mining, a place for bathing and washing as well as serving as a lavatory, hospital, hotel, settlements, and industry. Utilization of the river as a wastewater disposal site can cause a decrease in the quality of river water. The purpose of this research was to analyze the Belawan river water quality spatially. Water sampling was taken at nine points which included three upstream segment points in Deli Serdang District, three middle segment points in Deli Serdang District and Medan City, and three downstream segment points in Deli Serdang District. Based on the results of the research it can be concluded that the value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) at several monitoring points in Belawan river has exceeded the water quality standard limits of class I Government Regulation of Republic of Indonesia Number 82 the year 2001 and North Sumatera Governor Regulation Number 21 the year 2006.

1. Introduction

A river is a place for the existence of ecosystems that have an important role and provide benefits for living things. The provided benefits by the river are source of drinking water, habitat for organisms, settlements, agriculture, and industry. If these activities are not well managed, it will have an impact on decreasing river water quality. Belawan river is one of the rivers in North Sumatera Province with a length of 53 km. Belawan river administratively crosses Deli Serdang District and Medan City. Geographically Belawan watershed is in position: 98° 29' 47,868" - 98° 42' 35,496" E, 03° 50' 23,676" - 03° 15' 24,036" N [1].

The increasing number of the population followed by increase the daily need of clean water, including sanitation needs which produce wastewater. Pollution of water can cause disruption to the growth and development of aquatic organisms, the emergence of disease vectors that can cause dysentery in humans, and cause unpleasant odors [2]. The amount of waste discharged into river water both liquid and solid can cause an increase the value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). These waste can be sourced from the activities of agriculture, settlements, and the disposal of sludge generated from the drinking water treatment plant [3].
The monitoring results of The North Sumatera Province Environmental Service in 2014 to 2018 at several Belawan river monitoring points showed that the BOD and COD value has exceeded the class I water quality standard limits of Government Regulation of Republic of Indonesia Number 82 the year 2001 concerning Quality Management Water and Water Pollution Control and North Sumatera Governor Regulation Number 21 the year 2006 concerning Determination of River Water Quality and River Segmentation Standard. However, this monitoring has only been carried out at several monitoring points and monitoring has not yet been carried out entirely from upstream to downstream of the Belawan river. Changes in land cover can cause changes in river water discharge that affect the pollution dilution process to increase the BOD and COD value [4]. Some indicator of river water pollution can be seen from the high value of BOD and COD. High BOD and COD value indicate that more pollutants are derived from wastewater [5]. Based on the background of the above problems, the aim of this research is to analyze the Belawan river water quality through spatial observation.

2. Methodology

2.1. Study sites
The research was conducted using a quantitative descriptive approach. A descriptive method with quantitative approach in this research was used to describe the condition of the Belawan river water quality. This research was conducted on July 20, 2019. Water sampling was taken at nine points which included three upstream segment points in Deli Serdang District, three middle segment points in Deli Serdang District and Medan City, and three downstream segment points in Deli Serdang District.

![Figure 1. Map of Belawan River](image-url)
2.2. Quality assessment of river water
Sampling was carried out based on SNI 6989.57.2008 concerning The Method of Sampling Surface Water. River water samples that have been taken are then analyzed in laboratory to determine the concentration of water quality parameter. Water quality test data that includes BOD and COD parameter are compared with the established river water quality standard. The river water quality standard used refers to class I water quality standard of Government Regulation of Republic of Indonesia Number 82 the year 2001 concerning Quality Management Water and Water Pollution Control and North Sumatera Governor Regulation Number 21 the year 2006 concerning Determination of River Water Quality and River Segmentation Standard. Data processing to describe the Belawan river water quality uses Geographic Information System (GIS) with spatial data processing (ArcMap).

3. Results and Discussion
The results of the research showed that Belawan river water quality can be shown on table 1 and table 2. Based on BOD and COD parameter at several Belawan river monitoring points classified into class I quality standard threshold of Government Regulation of Republic of Indonesia Number 82 the year 2001 and North Sumatera Governor Regulation Number 21 the year 2006.

Table 1. BOD value of the Belawan river.

| No. | Location | Segment | BOD (mg/L) | Water quality standard (mg/L) |
|-----|----------|---------|------------|-------------------------------|
| 1   | Sta 1    | Upstream| 1.4        | 2                             |
| 2   | Sta 2    |         | 1.7        | 2                             |
| 3   | Sta 3    |         | 2.3        | 2                             |
| 4   | Sta 4    | Middle  | 3.1        | 2                             |
| 5   | Sta 5    |         | 4.2        | 2                             |
| 6   | Sta 6    |         | 6.2        | 2                             |
| 7   | Sta 7    | Downstream| 5.5      | 2                             |
| 8   | Sta 8    |         | 5.3        | 2                             |
| 9   | Sta 9    |         | 5.5        | 2                             |

Based on table 1, the BOD measurement of the Belawan river water at Sta 1 to Sta 9 showed that the BOD value ranges from 1.4 to 6.2 mg/L. BOD value at Sta 3 to Sta 9 has exceeded class I river water quality standard. Based on the Government Regulation of Republic of Indonesia Number 82 the year 2001 and North Sumatera Governor Regulation Number 21 the year 2006 requires that the class I river water quality BOD parameter is 2 mg/L. An increase of BOD value occurs at Sta 3. High BOD value in water can be sourced from domestic and agricultural waste disposal [6]. A high BOD value can also cause a decrease of oxygen value in the water [7]. This condition is influenced by activities in the upstream and middle segment of the Belawan river. In the upstream segment of the Belawan river there are plantation and agricultural activities. The high land use in Sibolangit, Kualimbaru, and Panceur Batu Sub-Districts for agricultural activities is one factor in the high use of the Belawan river water for agricultural irrigation. High agricultural activities will produce high waste from the use of fertilizers. This activity can increase organic compounds in the water. High organic compounds in the water can be seen from the high BOD value [8].
In addition, in the upstream segment of the Belawan river there are also a place for bathing and washing as well as serving as a lavatory activities in Belawan river because there are still no clean water channels in several settlements. While in the middle segment of the Belawan river, there are many activities such as settlements, hotel, and industrial activities. The high level of disposal from this activity can cause the BOD value in the middle segment of the Belawan river to be higher due to the addition of waste disposal sourced from the upstream segment of the Belawan river. In addition, there is a lot of waste that is not managed in the water of the Belawan river.

| No. | Location | Segment   | COD (mg/L) | Water quality standard (mg/L) |
|-----|----------|-----------|------------|-------------------------------|
| 1.  | Sta 1    | Upstream  | 8.01       | 10                            |
| 2.  | Sta 2    |           | 9.57       | 10                            |
| 3.  | Sta 3    |           | 13.26      | 10                            |
| 4.  | Sta 4    | Middle    | 17.89      | 10                            |
| 5.  | Sta 5    |           | 23.87      | 10                            |
| 6.  | Sta 6    |           | 37.92      | 10                            |
| 7.  | Sta 7    | Downstream| 31.23      | 10                            |
| 8.  | Sta 8    |           | 30.34      | 10                            |
| 9.  | Sta 9    |           | 30.21      | 10                            |

Based on table 2, the COD measurement of the Belawan river water at Sta 1 to Sta 9 showed that the COD value ranges from 8.01 to 37.92 mg/L. The COD value at Sta 3 to Sta 9 has exceeded class I river water quality standard. Based on the Government Regulation of Republic of Indonesia Number 82 the year 2001 and North Sumatera Governor Regulation Number 21 the year 2006 requires that the class I river water quality COD parameter is 10 mg/L. Same with the BOD parameter, an increase of COD value also occurs at Sta 3. The high value of COD can be caused by many activities that dump chemical waste into river water [9]. High COD value indicate that there are many pollutants in river water [6]. A high COD value can cause the amount of oxygen in the water to go down [10]. The high COD value in the middle segment of the Belawan river is influenced by activity in the upstream and middle segment of the Belawan river. In the upstream segment of the Belawan river, there are many plantation and agricultural activities. The high activities of plantation and agriculture cause high use of pesticide. In addition, waste discharges originating from dense settlements, hotel, and industrial activities in the middle segment of the Belawan river can be the cause of the high value of COD in river water. Increasing the population will certainly also cause the potential for an increased pollution burden [11].

Spatial distribution for BOD and COD pollutants is presented to clarify the spatial location of pollution and identify existing activities around the Belawan river. This is needed for handling the Belawan river pollution control. Spatial distribution of BOD parameter in Belawan river from upstream to downstream, is presented in Figure 2. Spatial distribution of COD parameter in Belawan river from upstream to downstream, is presented in Figure 3.
Figure 2. BOD spatial distribution in Belawan river from upstream to downstream.
Figure 3. COD spatial distribution in Belawan river from upstream to downstream
4. Conclusions
The result on Belawan river water quality measurement showed that water pollution occurs from the upstream to downstream segment as indicated by the presence of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) at Sta 3 to Sta 9 has exceeded the water quality standard limits of class I Government Regulation of Republic of Indonesia Number 82 the year 2001 and North Sumatera Governor Regulation Number 21 the year 2006. The high value of BOD and COD can be caused by various activities based on land use and disposal of waste generated into the water of the Belawan river such as plantation, agriculture, settlements, hotel, and industrial activities.

References
[1] The North Sumatera Province Environmental Service 2017 Report of implementation Belawan and Deli river water quality monitoring p 3
[2] Yustiani Y M and Komariah I 2017 Investigation on the biodegradation capacity of urban rivers in Jakarta (Indonesia) International Journal of Geomate 12 pp 45-50
[3] Yustiani Y M, Wahyuni S and Saputra A 2018 Analysis study of water quality in Cibanten river (Serang Districts, Banten Province) Journal of Community Based Environmental Engineering and Management 2 pp 13-20
[4] Soukotta E, Ozsaer R and Latuamury B 2019 The chemical quality analysis of the water of Riuapa river and its impact on the environment Small Island Forest Journals 3.1 pp 86-96
[5] Azizah M and Anen N 2019 Water quality status of Cikaniki Bogor Districts based on pollution and diversity of macrofauna Florea: Journal of Biology and Learning 6.2 pp 79-87
[6] Anhwange B A, Agbaji E B and Gimba E C 2012 Impact assessment of human activities and seasonal variation on Benue river International Journal of Science and Technology 2.5 pp 248-254
[7] Pohan, Saleh D A, Budiyono B and Syafrudin 2016 Analysis of river water quality in determining designation in terms of environmental aspects Journal of Environmental Sciences 14.2 pp 63-71
[8] Yudo S 2010 The condition of Ciliwung river water quality in DKI Jakarta Region in terms of organic (ammonia, phosphate, detergent and coli bacteria parameters) Indonesian Aquaculture Journal 6.1 pp 34-42
[9] Yohannes B, Utamo S W and Agustina H 2019 River water quality study and water pollution control (study in Krukut River, South Jakarta) IJEEM: Indonesian Journal of Environmental Education and Management 4.2 pp 136-155
[10] Sara P S, Astono W and Hendrawan D I 2018 Study of water quality in the Ciliwung river with BOD and COD parameters Proc. The National Scholar Seminar in Jakarta pp 591-7
[11] Rahayu Y, Juwana I and Marganingrum 2018 Study of calculation of river water pollution load in Cikapundung river basin from domestic sector Green Engineering Journal 1.2 pp 1-11