Study of river water quality in various land cover of Percut Watershed at Deli Serdang Regency

Machairiyah	extsuperscript{1*}, Z Nasution	extsuperscript{2} and B Slamet	extsuperscript{3}

	extsuperscript{1}Department of Natural Resources and Environmental Management, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

	extsuperscript{2}Faculty of Agriculture, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

	extsuperscript{3}Faculty of forestry, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

E-mail: *machairiyah@gmail.com

Abstract. Land use is closely related to changes in the quality and quantity of river water. River damage due to changes in land cover is influenced by human activities in land use so that there is an increase in open and built areas. Percut River is one of the rivers flowing in the city of Medan, Karo district and Deli Serdang district, which receives the effects of industrial, residential and agricultural waste pollution. This study aims to analyse the water quality of Percut River both physically and chemically representing the upstream to downstream of the Percut River with various surrounding land cover. There are 5 sampling points on the Percut River. Analysis of river water quality was using the water quality index and pollution index. The water quality status of Percut River is slightly polluted. The results of the Percut River water quality analysis showed several parameters exceeding the quality standard based on government regulation PP No.82 of 2001 Class II namely the parameters COD, ammonia, phosphate. The value of each Percut River water quality parameter is different for each type of land cover or land use. Downstream areas are the areas that receive the greatest impact from pollution.

1. Introduction

Land use has an essential influence on the condition of the quality and quantity of river water. Conversion or clearing of land that does not use the principle of environmental sustainability can lead to many negative things, not only in the stage of clearing but also in the stages of their use and management. Land use is an important part that influences river water quality [1]. The development and increasing activities of human activities in land use, such as industrial activities, agriculture, settlements cause pollution [2]. The decrease in water quality could be check by changes in physical, chemical, and biological [3]. A river stated was polluted if its water quality is not following its designation. This pollution is closely related to land-use changes that occur, if the burden of input of dissolved materials exceeds the ability of rivers naturally to clean themselves (self-purification) [4] so that it affects the life of aquatic biota and the health of the population around watersheds that utilize the water.

Percut River dominated by various variations of land cover in the form of forests, ponds, settlements, agriculture, plantations and vacant land. The study aim was to analyse the effect of various land cover on Percut Watershed could reduce the quality of Percut River water. The water
quality of the Percut River was analysed by the WQI method and the Pollution Index. The use of indices makes it easier to evaluate a water thoroughly and more objectively so that it can be known the cause of the low index due to the high pollutant load of a parameter under study, so it is easy to determine the right management pattern. The parameters analysed were turbidity, TSS, temperature, pH, BO, BOD, COD, nitrate, nitrite, ammonia, and phosphate on the status of Percut River water quality. This analysis is useful for the government and related parties to find out the correct handling in the management of pollution waste that occurs in the Percut River.

2. Materials and methods
The material used in this study is 2017 land cover map from the North Sumatera BPKH office, Percut Watershed map, river network maps downloaded from the RBI and administrative map of Deli Serdang District. Changes in land cover in 2017 were analysed by the spatial method of ArcGIS by overlaying land cover maps, river network maps, and Percut Watershed maps.

![Figure 1. Land cover maps and sampling points of Percut Watershed](image)

**Table 1. Sampling points**

| The Sampling point                  | Land cover                                                   |
|------------------------------------|--------------------------------------------------------------|
| Point 1 Bukum Bridge Sibolangit    | The upstream area is a forest area, agriculture              |
| (3° 14’58.2” N and 98° 33’54.9” E)|                                                              |
| Point 2 Sarilabajahe Bridge– Sibiru-biru | Agricultural areas, paddy fields, open land, and tourism areas |
| (3° 21’47.355” N and 98° 40’2.58” E) |                                                              |
| Point 3 Amplas Bridge              | The settlement, urban and industrial areas                   |
| (3° 32’20.2218” N and 98° 42’47.982” E) |                                                              |
| Point 4 Tembung Bridge             | Residential area                                             |
| (3°35’46.92552” N and 98° 44’42.258” E) |                                                              |
| Point 5 Paluh Merbau Bridge        | The downstream area is an area of ponds, swamps, paddy fields, open land |
| (3°43’15.213” N and 98°44’57.396” E) |                                                              |

Sampling points were determined by using purposive sampling method, based on consideration of ease of location access, time efficiency, cost, and instant sampling or grab sampling [5]. Five sampling
3 points from upstream to downstream of the Percut River present in Fig 1. Each point represents the dominant area or land cover.

Water quality parameters analysed in situ and ex situ (laboratory analysis). The data were analysed using WQI (water quality index) and Pollution Index method based on PP No. 82 of 2001 concerning class II water quality classification. Evaluation of IP values is as follows:

\[
IP_j = \sqrt{\left(\frac{C_j}{L_j}\right)^2_a + \left(\frac{C_j}{L_j}\right)^2_b}
\]

(1)

| Score | criteria                       |
|-------|--------------------------------|
| 0.0 ≤ PIj ≤ 1.0 | Good Water Quality |
| 1.0 ≤ PIj ≤ 5.0  | slightly polluted          |
| 5.0 ≤ PIj ≤ 10   | fairly polluted             |
| PIj > 10         | heavily polluted            |

Formula:

\[
WQI = \sum_{i=1}^{n} w_i q_i
\]

(2)

WQI is water quality index, a number between 0 and 100, wi is unit weight of the ith parameter, a number between 0 and 1, qi is quality of the ith parameter, a number between 0 and 100, n = number of parameters. WQI classification criteria is as follow the Table 3 [6].

| WQI score | Criteria     |
|-----------|--------------|
| 0 – 20 %  | Very bad     |
| 21 – 40%  | Bad          |
| 41 – 60%  | Medium       |
| 61 – 80%  | Good         |
| 81 – 100% | Excellent    |

Data analysis carried out in descriptive. Quantitative research was used to describe the condition of Percut River water quality from land use activities from upstream to downstream in the form of forests, ponds, settlements, industries, agriculture, and plantations.

3. Results and discussion

Geographically the Percut Watershed is at 3°10’40.87” to 3°46’20.77” N and meridians 98°32’01.20” to 98°48’02.88” E with the main river through it is the Percut River. The area of Percut Watershed is 412.26 km².

3.1. Land cover

Analysis of the type of land cover in the Percut Watershed is analysed by a spatial method that is overlaying the 2017 land cover map with the Percut Watershed map. The results can be seen from the Table 4.
Table 4. Land cover in 2017

| Land cover                      | Area (Ha) |
|--------------------------------|-----------|
| Waterbody                      | 194.18    |
| Shrubs                         | 326.77    |
| Swamp mixed with shrubs        | 1,195.01  |
| Primary dryland forest         | 4,399.90  |
| Secondary dryland forest       | 81.51     |
| Mangrove                       | 269.69    |
| Settlement                     | 10,768.40 |
| Plantation                     | 4,297.94  |
| Dryland Agriculture            | 12,878.35 |
| Rice fields                    | 3,439.22  |
| Ponds                          | 3,292.99  |
| Open area                      | 82.47     |

The Table 4 above shows the existence of several types of land cover, where the dominant land cover is in the form of dryland agriculture and settlement. Land use is a result of human activities in meeting their needs.

3.2. Parameters analysed
Various land covers in the Percut River affect the water quality of the Percut River. Water sampling was carried out two times, with three replications over two weeks. The results of the current quality of the Percut River can be found in Table 5 show the quality of Percut River water from upstream to downstream. Each sampling point has a different water quality parameter value depending on the condition of land cover or land use around the sampling point.

Table 5. Results of parameter quality water

| No | Parameter                                | Unit  | Quality standard | Sampling points |
|----|------------------------------------------|-------|------------------|-----------------|
|    |                                          |       |                  | I   | II  | III | IV  | V   |
|    |                                          |       |                  | 15  | 10  | 1.5 | 20  | 1.5 |
| 1  | Turbidity                                | NTU   | 16.9             | 38.56| 46.365| 31.95| 12.355|
| 2  | TSS                                      | mg/l  | 50               | 4   | 1   | 1   | 1.5 |
| 3  | Temperature                              | °C    | Deviation 3      | 22  | 25.5| 27  | 28  | 29  |
|    |                                          |       |                  | 6 - 9| 7.2 | 7.4 | 6.25| 6.35| 6.95|
|    |                                          |       |                  | 25  | 48.95| 26.5| 12.25| 12.25| 65.3 |
|    |                                          |       |                  | >4 | 9.45 | 11.2| 11.75| 10.05| 9.55 |
|    |                                          |       |                  | 3 | 1.66 | 1.215| 1.76 | 2.39 | 4.05 |
|    |                                          |       |                  | 10 | 0.017| 0.021| 0.316| 0.016| 0.017|
|    |                                          |       |                  | 0.06| 0.008| 0.0105| 0.158| 0.008| 0.009|
|    |                                          |       |                  | 0.2 | 0.1265| 0.0135| 0.042| 0.0365| 0.3455|
|    |                                          |       |                  | 0.5 | 2.945| 1.315| 0.755| 1.25 | 2   |
3.2.1. Physics. Turbidity, TSS, and temperature are one of the physical parameters in determining river water quality. Based on the results of laboratory analysis, the highest turbidity at sampling point 3 is the Amplas Bridge. The temperature of the Percut River is normal because it has a deviation of 3 from the natural temperature conditions in the local environment. The temperature influences the ability of water to absorb oxygen from the air [7].

3.2.2. Chemistry. There are eight chemical factors analysed in this study, with values at each sampling point vary greatly. The ability of river water to clean itself naturally from various contaminants and pollutants (self-purification) is one of the factors that influence water quality. The processes that occur include physical dilution, dispersion and deposition, chemical reactions, adsorption. Waste entering the river flow is spread (non-point source).

The minimum dissolved oxygen concentration (DO) is 4 mg/l [6]. DO conditions in Percut River water at all locations where sampling points still meet the quality standard requirements. It means the condition of Percut River waters is good indicates the low temperatures increase the amount of DO in the waters. The low water pH in downstream indicates the unhealthy condition caused by industrial and domestic waste. pH conditions also affect the value of BOD5, phosphate, nitrogen, and other nutrients. Phosphate causes eutrophication in river flow [9]. Total phosphate at each station is low except in the highest downstream area with a concentration of 0.452.

BOD5 parameter is getting downstream the higher, and this shows that the increasing burden of organic pollutants entering the Percut River. The COD parameter also shows an indication of organic pollution [10] and the highest COD value in the downstream of the Percut River and exceeds the quality standard. Total amount of organics contained in the water is expressed with a high COD content and is an indication of organic material pollution [11]. Organic matter comes from rotting litter.

3.3. Water quality status

The status of Percut River water according to the WQI method is of medium criteria (Eq.2) and the method of polluted index is slightly polluted (Eq.1). The parameters analysed by the WQI method are temperature, pH, turbidity, DO, and BOD5, while the parameters analysed with pollution indices are TSS, COD, nitrate, nitrite, phosphate, and ammonium.

Table 6. The status of Percut River water

| No | Parameter                                | Method                                  | Water Quality Status / criteria |
|----|------------------------------------------|-----------------------------------------|--------------------------------|
| 1  | Temperature                              | WQI (lohani, 1984)                      | Medium (54.55%)                |
| 2  | pH                                       | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (3.5109)     |
| 3  | Dissolved Oxygen (DO)                    | WQI (lohani, 1984)                      | Medium (52.19%)                |
| 4  | Turbidity                               | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (2.5265)     |
| 5  | Biochemical Oxygen Demand (BOD)          | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (2.2961)     |
| 6  | Total Suspended Solid (TSS)              | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (2.1614)     |
| 7  | Chemical Oxygen Demand (COD)             | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (3.319)      |
| 8  | Nitrate                                 | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (2.2961)     |
| 9  | Nitrite                                 | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (2.1614)     |
| 10 | Phosphate                               | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (3.319)      |
| 11 | Ammonia                                 | IP based on quality class II government regulation PP No. 82 of 2001 | slightly polluted (3.319)      |
The condition of Percut River water quality is slightly polluted, the parameters of temperature, turbidity, pH, BOD and DO which cause the low value of the WQI parameter need to be carried out proper waste management. Each industry must first manage its waste (water treatment) before disposing it and flowing it into the river. People are advised not to dump domestic waste into rivers and use fertilizer effectively in agricultural areas. Industrial and household activities that dispose of waste into rivers must be stopped.

3.4. Land cover type at sampling points

3.4.1. Point 1 Bukum Bridge. In this area is the upstream area of the Percut River, Sibolangit area and a small part of Karo Regency in the form of forest and agricultural land with parameter results showing that the high COD and ammonia parameters exceed quality standards. The condition of Percut River water quality in the upstream area is slightly polluted. Changes in the use of forests land into settlements and agriculture affect changes in water quality in the Upper Percut’s river. This can be seen from the Table 5 that the high value of ammonia, COD parameters and the presence of nitrate, nitrite and phosphate due to domestic waste from human activities and originating from the use of agricultural land carried by river flow due to erosion or surface runoff where strong currents can erode soil and sand around rivers that carry nutrient material.

3.4.2. Point 2 Sarilabajahe Bridge. The area dominated by land cover in the form of agriculture, rice fields, open area, and the existence of Sibiru-Biru river tourism activities. There is organic matter pollution seen from the high value of COD. Waste originating from agricultural and plantation activities around the river entering the Percut River. Organic matter is waste that is easy to rot and is degraded by microorganisms derived from litter, leaves, stems. COD value exceeds quality standards but is not contaminated (COD> 200 mg / l) [7]. The presence of ammonia as due to domestic waste and tourism activities in the form of washing with the use of detergents or bathing with the use of soap. Parameters of phosphate, nitrites originated from rice fields or agricultural areas brought into the river pollute of river even though in little amounts that do not exceed quality standards.

3.4.3. Point 3 Amplas Bridge. The area was the transition between upstream and downstream areas, in the form of residential areas, urban centres, and industries. The sampling point of water withdrawal is under Amplas Bridge, which receives waste from the surrounding area in the form of domestic waste from settlements and industrial waste. Polluted water quality conditions showed by the values of the turbidity, ammonia, and high-temperature parameters. The human activities around the Percut River influence the water quality, including the habit of disposing of garbage to the river. High ammonia levels indicate polluted river water. The concentration of nitrite exceeds the quality standard, its closely related to human and industrial activity nearby. The unproper wastewater management before being discharged or flowed into the river could lead the highly polluted water.

3.4.4. Point 4 Tembung Bridge. This area dominated by a residential area with a high population density. Domestic waste dominates pollutants at this point. The BOD5 parameter is high in this region due to domestic waste discharged into the river, the decay of aquatic biota and the habits of the people who throw garbage into the river. Along the river’s bank is used as a dumpsite for the community. The amount of pollution load that influences the physical and chemical conditions of the Percut River characterized by high turbidity, ammonia, and temperature parameters at this point.

3.4.5. Point 5 Paluh Merbau Bridge. The downstream area dominated by ponds, swamps, agricultural land (rice fields), and mangroves. The highest COD value in the downstream area and the lowest DO value, and this causes the water's ability to self-purification is low because of the low availability of dissolved oxygen. Other parameters, namely BOD5, ammonia, phosphate downstream, are increasing due to the accumulation of organic matter and nutrients derived from fertilizers carried by the river.
flowing downstream. High ammonia in the downstream area exceeds the quality standard indicating polluted water quality. Ammonification process that occurs comes from the breakdown of organic matter by microbes [8]. Domestic and industrial wastewater is a constant source of pollutants, while surface runoff is seasonal depending on climate condition. During the rainy season, conditions in the downstream experience the effects of all activities that occur upstream. Surface runoff causes much waste to be carried and flow downstream.

4. Conclusion
Changes in land use cause an increase in the burden of pollutants entering the body of the river and ultimately the quality of the environment, which decreases. The dominant organic matter causes a decrease in water quality in the Percut River. Increased domestic, agricultural, and industrial activities will influence and have an impact on river water quality conditions. Physical and chemical parameters analysis show that the water quality of Percut River is slightly polluted. Pollutant load that enters the river has exceeded the ability of the river for self-purification. The amount of waste or pollutant load that enters the Percut River if not controlled will cause a decrease in water quality which will ultimately disrupt the aquatic ecosystems in the Percut River.

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