Habitat characteristics and water quality status in the Batangtoru Watershed, North Sumatra Province, Indonesia

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Abstract. The Batangtoru watershed is one of the aquatic ecosystems in maintaining the presence of natural aquatic biodiversity in the Tapanuli region. This study aims to describe the habitat characteristics of aquatic organisms and determine the status of the water quality of the Batangtoru watershed by the Sing score method. Sampling was carried out for 20 days from 21st of July to 10th of August 2019. Determination of 1 - 34 sampling points was carried out by purposive sampling method based on the representation of the overall environmental conditions of the Batangtoru watershed reflecting upstream, middle, downstream and creeks while taking into account the level of safety during sampling in the field. Based on the calculation results of Sing Score method, it also shows that in general the conditions of the waters in the Batangtoru watershed is still fair to excellent. But there are some points that are already poor, namely at point 5. Excellent water conditions are always found in creeks and sub-tributaries.

1. Introduction
River Basin (DAS) is a unified terrestrial ecosystem with rivers and their tributaries. Indonesia has a watershed area of 1,512,466 km² of the 16,958 total Indonesian watershed and Sub-watershed. The watershed originates from at least 5,590 major rivers and 65,017 tributaries with the total length of the main river reaching 94,573 km [1]. Ministry of environment [2] reported that 30.62 percent (5,193 watersheds) had no forests and 15.75 percent (2,672 watersheds) only had forest areas below 30 percent. Whereas according to the National Spatial Planning Law and the Ministry of Forestry Law, forest cover in a watershed should be greater than 30 percent, of the total watershed area.

The Batangtoru watershed is one of the watersheds in Indonesia that is experiencing damage due to changes in the surrounding land use. The Batangtoru watershed stretches across the Tapanuli region from Siborong-borong (North Tapanuli) to Batangtoru (South Tapanuli) and empties into Batu Mundom (Mandailing Natal) on the West Coast of Sumatra. Batangtoru watershed has an area of 303,181.82 ha with the main river length reaching ± 174 km [6]. The average annual / day discharge of the Batangtoru River is 106 m³s⁻¹, with a minimum debit of 41.90 m³s⁻¹ and the maximum discharge reaching 484 m³s⁻¹ [7].

Thus the Batangtoru watershed is the main ecosystem in maintaining the presence of water in North and South Tapanuli. Besides having a hydrological function, the Batangtoru watershed plays an important role in maintaining biodiversity, economic value, culture, transportation, tourism and others in the Tapanuli region. In the context of maintaining biodiversity, the Batangtoru watershed plays an
important role as a habitat for various aquatic organisms, such as fish, crustaceans, macroinvertebrates and other aquatic organisms. Therefore, it is important to study the characteristics of habitat and water quality of the watershed as part of the ongoing management of the Batangtoru watershed. In addition, determining the status of water quality is the first step in the management of the Batangtoru watershed ecosystem.

2. Method

2.1. Study site
Location of habitat data collection and macroinvertebrate biodiversity along the watershed Batangtoru (Figure 1), which are 34 points. Sampling was carried out for 20 days from 21th July to 10th August 2019.

2.2. Sampling method
Mapping measurement of habitat conditions by measuring water-physico-chemical parameters and measured directly in the field. Mapping of habitat use gps tracking. Meanwhile, macroinvertebrate (upstream) is collected by a Surber net (mesh size 1 mm) which is operated by stirring up the sediment (substrate) of the riverbed. Also included macroinvertebrate, which attaches to stones, wood and plastic that found in water bodies. The identification of macroinvertebrate Referred [9].

2.3. Data processing procedure and data analyse
All data collected concerning habitat and macroinvertebrate will analyse qualitatively and quantitatively. Further evaluation of river habitat based on macroinvertebrate with method SingScore [10,11]. The SingScore formula:

\[ SingScore = \frac{\sum_{i=1}^{S} a_i}{S} \times 20 \]  

where S = the total number of taxa in the sample and ai is the tolerance value for the i taxon

SingScore category is Likely Water Quality: 0–79 Poor; 80–99 Fair; 100–119 Good; and 120+ Excellent

3. Results and discussions

3.1. Physical-chemical and habitat characteristic
Based on the results of field surveys, land use around the location of data collection in the Batangtoru watershed is generally an agriculture area (rice fields and farms), settlements, and includes a gold mine. Only a small portion of the forest area is point 8-10 and 15.18.31, and 34 (7 points or 17.65%). Some areas, especially Siborong-borong and Tarutung areas are agricultural and plantation areas. While the forest area is in the Pahae and Marancar areas (Dolok Sibual-buali Forest). The diversity of this land use will provide opportunities for declining river water quality because of the potential input coming from human activities along the watershed. The conditions around the observation location are shown in Table 1.

In general, river slope conditions in the Batangtoru watershed are steep, except at some points are categorized sloping in the middle (Tarutung area) and flat in the downstream. Meanwhile, the type of substrate in the Batangtoru watershed is quite varied. In the upstream part of the Batangtoru watershed the substrate type is sandy (Siborong-borong) and only in the Sidagal area are rocky and gravel type (31). In the middle part of the observation site are generally sand and gravel substrate types. There is an interesting thing, in the middle part (location 21) is a steep and narrow area with a rocky substrate type. At the downstream part the substrate is muddy sand type. While in the creeks and sub-tributaries the substrate was gravel and rocky. The rocky substrate and fast flowing water condition indicates the upstream river segment, as the results of the study of Muhtadi et al. [4]) and Desrita et al. [5]. Rivers
in the upstream are characterized by large rocky substrates, heavy streams, and narrow river widths [12,13]. Furthermore, Muhtadi et al. [3,4] state the characteristics of the river headwaters are also characterized by large slopes and narrower river widths. The condition of the substrate is also very influential on the level of brightness and colour of the waters. At the point of observation with sandy and / or muddy substrate tends to turbid waters.

In general, locations with high current velocity are in locations with rocky substrates and steep and narrow river conditions. This is evident in the observation point at point 31 (Sidagal) with a steep and narrow location where the current of the river reaches 1.32 m/s. While in the condition of wide river and sloping have a lower current velocity, as seen in the downstream (0.2 - 0.5 m/s) even almost no flows (points 1 and 4). At the highest observation points including upstream and tributaries show low current and discharge velocity. This is related to the increasingly narrow watershed area in the upstream and tributaries, so that the volume of water collected is lower than at the bottom. At locations 21 and 31, rock cliffs were found. Therefore, the slope at this point is steeper than at other locations. This slope and narrow river width that causes the higher currents at these locations.

The temperature range in the waters of the Batangtoru watershed is 20.5 - 29.0 °C. High temperatures are found in the downstream location (reaching 28.5 °C) and the middle (point 5) which reaches 29 °C. The high temperature in both locations is related to altitude and the presence of land cover around. At locations 1 and 5 are areas where tree cover rates are much lower than other segments. Temperature values in the waters upstream of the Batangtoru watershed still show normal values and are still suitable for aquatic biota life.

The pH value in the upstream waters of the Batangtoru watershed ranges between 7.1 - 8.7. The pH value of the waters in the upstream tends to be alkaline, due to the low organic matter in the upstream so that the level of organic decomposition is low. The high pH is also caused by a large number of sulphur sources in the Batangtoru watershed, especially around Marancar - Sipirok, and Pahae. The pH value still meets the quality standard and suitable for the life of fish and another aquatic biota [14].

The concentration of dissolved oxygen in the Batangtoru watershed ranges from 2.8 - 8.7 mg / L. Generally, the measured oxygen is high, except at the estuary (1). This is the low flow and turbidity of transmission at these locations. The high concentration of dissolved oxygen in other locations is due to strong currents in this area. Flowing waters tend to have high dissolved oxygen content compared to stagnant waters because the movement of water provides an opportunity for oxygen diffusion from air to water [4,12]. This can be seen in table 1, where the high current sampling location shows a high DO value in each data collection segment.

3.2. Status and condition of waters

In general, the condition of the waters in the Batangtoru watershed is still in the good category. Based on the description of water quality (measurement in situ) shows the values of parameters that are good for the life of aquatic organisms. Environmental parameters that become limiting factors in the Batangtoru watershed are a substrate and current characteristics. Currents are the main limiting factors of life and abundance of aquatic organisms in rivers [4,5]. Mahseer fish and mountain catfish are river water organisms that like and are able to survive in strong current waters. Loach fish is one of the fish that likes currents (low-medium) with clear waters. Therefore, Loach fish has always been found in very good locations.
### Table 1. Aquatic environment condition at study site

| Environment parameter | Site location |
|-----------------------|---------------|
|                       | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  |
| pH                    |    |    |    |    |    |    |    |    |
| Conductivity          |    |    |    |    |    |    |    |    |
| TDS (mg/l)            |    |    |    |    |    |    |    |    |
| DO (mg/l)             |    |    |    |    |    |    |    |    |
| Clear Water Temp. (°C)|    |    |    |    |    |    |    |    |
| Deforestation         |    |    |    |    |    |    |    |    |
| Sand and gravel       |    |    |    |    |    |    |    |    |
| Turbidity             |    |    |    |    |    |    |    |    |
| Substrate             |    |    |    |    |    |    |    |    |
| Wetted river (m)      |    |    |    |    |    |    |    |    |
| Flow (m/s)            |    |    |    |    |    |    |    |    |
| Debit (m³/s)          |    |    |    |    |    |    |    |    |
| Visible color         |    |    |    |    |    |    |    |    |

### Table 1. Aquatic environment condition at study site (continue)

| Environment parameter | Site location |
|-----------------------|---------------|
|                       | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| pH                    |    |    |    |    |    |    |    |    |    |
| Conductivity          |    |    |    |    |    |    |    |    |    |
| TDS (mg/l)            |    |    |    |    |    |    |    |    |    |
| DO (mg/l)             |    |    |    |    |    |    |    |    |    |
| Clear Water Temp. (°C)|    |    |    |    |    |    |    |    |    |
| Deforestation         |    |    |    |    |    |    |    |    |    |
| Sand and gravel       |    |    |    |    |    |    |    |    |    |
| Turbidity             |    |    |    |    |    |    |    |    |    |
| Substrate             |    |    |    |    |    |    |    |    |    |
| Wetted river (m)      |    |    |    |    |    |    |    |    |    |
| Flow (m/s)            |    |    |    |    |    |    |    |    |    |
| Debit (m³/s)          |    |    |    |    |    |    |    |    |    |
| Visible color         |    |    |    |    |    |    |    |    |    |

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**Table 1.** Aquatic environment condition at study site (continue)

| Environment parameter | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|-----------------------|----|----|----|----|----|----|----|----|
| **Land use**          | paddy field and small forest | paddy field and farm | paddy field and small forest | paddy field and farm | paddy field and settlement | paddy field and settlement | paddy field and settlement | paddy field and settlement |
| **River slope**       | steep | steep | steep | slope | slope | slope | slope | slope |
| **Substrate**         | gravel and stones | sand and gravel | gravel and stones | sand and gravel | fine sand and muddy sand | fine sand and muddy sand | fine sand and muddy sand | fine sand and muddy sand |
| **Depth (m)**         | 0.2 - 0.6 | 0.3 - 1.0 | 0.3 - 1.0 | 0.3 - 2.0 | 0.5 - 1.5 | 0.5 - 1.6 | 0.3 - 1.0 | 0.3 - 0.5 |
| **Wetted river (m)**  | 15.20 | 10.0 | 12.0 | 5.0 - 10.0 | 20 - 25 | 60 - 100 | 30 - 35 | 1.5 - 3.0 |
| **River width (m)**   | 20 - 30 | 15.0 - 20.0 | 5.0 - 10.0 | 25 - 30 | 75 - 120 | 30 - 40 | 2.0 - 3.0 | 3.0 - 5.0 |
| **Flow (m/s)**        | 0.91-1.36 | 0.8 - 1.5 | 0.64 - 1.44 | 0.5 - 2.0 | 0.20 - 0.75 | 0.20 - 0.75 | 0.10 - 0.50 | 0.10 - 0.50 |
| **Debit (m³/s)**      | 4.64 | 5.00 | 2.06 | 28.00 | 25.00 | 15.00 | 0.18 | 0.27 |
| **Visible color**     | clear | turbidity | clear | turbidity | turbidity | turbidity | clear | turbidity |
| **Temperature (°C)**  | 22.5 - 22.8 | 22.5 - 23.0 | 22.5 - 22.8 | 21.9 - 22.0 | 23.1 - 24.0 | 23. - 24.0 | 23.0 - 24.0 | 27.5 - 28.0 |
| **TDS (mg/l)**        | 36 - 37 | 37 - 40 | 35 - 37 | 45 - 46 | 43 - 44 | 55 - 60 | 76 - 77 | 70 - 75 |
| **Conductivity**      | 75 - 77 | 77 - 80 | 75 - 77 | 91 - 92 | 65 - 67 | 70 - 74 | 115 - 117 | 150 - 155 |
| **DO (mg/l)**         | 8.0 - 8.4 | 7.0 - 8.0 | 8.0 - 8.4 | 7.4 - 8.0 | 6.9 - 7.4 | 6.9 - 7.5 | 6.0 - 6.5 | 6.5 - 7.0 |
| **pH**                | 7.4 - 7.7 | 7.1 - 7.5 | 7.4 - 7.7 | 7.5 - 7.6 | 7.3 - 7.5 | 7.2 - 7.5 | 7.0 - 7.2 | 7.0 - 7.5 |

**Table 2.** Aquatic environment condition at study site (continue)

| Environment parameter | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
|-----------------------|----|----|----|----|----|----|----|----|----|
| **Land use**          | dam | paddy field, settlement, and dam | paddy field, settlement, and dam | paddy field and small forest | Settlement and paddy field | paddy field | paddy field | farm and small forest |
| **River slope**       | slope | steep | steep | steep | steep | steep | steep | steep |
| **Substrate**         | sand and gravel | fine sand | fine sand | fine sand | fine sand and muddy sand | fine sand and muddy sand | fine sand and muddy sand | fine sand and muddy sand |
| **Depth (m)**         | 0.1 - 0.5 | 0.5 - 1.5 | 0.5 - 1.0 | 0.3 - 1.0 | 0.3 - 1.5 | 0.5 - 3.0 | 0.2 - 1.2 | 0.2 - 1.2 |
| **Wetted river (m)**  | 30.0 - 50.0 | 35.0 - 40.0 | 15.0 - 20.0 | 2.0 - 3.0 | 2.5 - 5.0 | 5.0 - 15.0 | 7.0 - 12.0 | 5.0 - 15.0 |
| **River width (m)**   | 30.0 - 50.0 | 40.0 - 50.0 | 15.0 - 25.0 | 2.0 - 5.0 | 3.0 - 7.0 | 5.0 - 15.0 | 10.0 - 15.0 | 7.0 - 15.0 |
| **Flow (m/s)**        | 0.41 - 1.05 | 0.1 - 0.5 | 0.50 - 0.10 | 0.12 - 0.58 | 0.10 - 0.52 | 0.97 - 1.66 | 0.63 - 1.38 | 0.60 - 1.50 |
| **Debit (m³/s)**      | 0.65 | 0.4 | 0.7 | 0.47 | 0.36 | 1.32 | 1.02 | 0.8 |
| **Visible color**     | turbidity | turbidity | turbidity | turbidity | turbidity | turbidity | turbidity | turbidity |
| **Temperature (°C)**  | 23.0 - 23.5 | 23.0 - 23.5 | 23.0 - 23.5 | 21.6 - 22.0 | 25.2 - 26.0 | 22.5 - 22.7 | 22.4 - 22.8 | 22.4 - 22.8 |
| **TDS (mg/l)**        | 69 - 74 | 50 - 60 | 58 - 59 | 67 - 68 | 38 - 39 | 58 - 60 | 27 - 28 | 27 - 28 |
| **Conductivity**      | 138 - 149 | 115 - 122 | 115 - 122 | 134 - 136 | 75 - 79 | 115 - 119 | 54 - 56 | 54 - 56 |
| **DO (mg/l)**         | 7.6 - 7.8 | 6.5 - 7.3 | 7.1 - 7.3 | 7.5 - 7.7 | 6.8 - 7.0 | 7.8 - 8.0 | 7.2 - 8.0 | 7.2 - 8.0 |
| **pH**                | 7.3 - 7.5 | 7.0 - 7.5 | 7.0 - 7.5 | 7.2 - 7.3 | 7.5 - 7.7 | 7.5 - 7.7 | 7.3 - 7.5 | 7.3 - 7.5 | 7.0 - 7.3 |
Based on the results of Singscore calculations also showed that in general, the water conditions in the Batangtoru watershed varied from poor (66.67) to excellent (140.00) (Fig 2). Poor conditions are found at point 5 (there is a mine) and best at point 9 at the Dolok Sibual-buali foothill. However, on average it shows that the status of water quality based on Singscore shows fair conditions in the down and middle streams and good in the upstream and excellent sections of creeks and sub-tributaries (see Table 2). At point 9, although 9 macroinvertebrates were found, only 9 families compared to other points that reached 11 families (point 16) but had the highest Singscore because families found were dominated by highly sensitive families such as Parathelphusidae, Heptageniidae, and Perlidae which had a score of 9 (maximum). This is still possible because out of 34 sampling locations, point 9 is the most natural point (virgin).

Based on the status of water quality in several other river basins in Indonesia, the Batangtoru watershed is still better than other river basins. For example, Patang et al [16] found polluted conditions in the Karang Mumus River (East Kalimantan). Water quality of Tumpang 2 irrigation channel was consistently categorized into good, fair, and probable moderate pollution [17].

**Table 2. Waters status at Batangtoru watershed based on singscore**

| Location   | Singscore (average) | Category |
|------------|---------------------|----------|
| Down stream | 84                  | Fair     |
| Middle stream | 92                | Fair     |
| Up stream   | 104                 | Good     |
| Tributaries | 126                 | Excellent|
| Sub tributaries | 124             | Excellent|

**Figure 1. Map of habitat condition based on singscore**

4. **Conclusions**

Based on the calculation results of Sing Score, the water conditions in the Batangtoru watershed varied from poor (66.67) to excellent (140.00). Poor conditions are found at point 5 (there is a mine) and best
at point 9 at the Dolok Sibual-buali foothill. However, on average it shows that the status of water quality based on Singscore shows fair conditions in the down and middle streams and good in the upstream and excellent sections of creeks and sub-tributaries (see table 2). At point 9, although 9 macroinvertebrates were found, only 9 families compared to other points that reached 11 families (point 16) but had the highest Singscore because families found were dominated by highly sensitive families such as Parathelphusidae, Heptageniidae, and Perlidae which had a score of 9 (maximum). This is still possible because out of 34 sampling locations, point 9 is the most natural point (virgin).

References

[1] Kementerian Pekerjaan Umum dan Perumahan Rakyat [Minister for Public Works and Human Settlements] 2017 Buku Statistik Pekerjaan Umum Tahun 2017 [Public Works Statistics Information Book] (Jakarta: Kementerian Pekerjaan Umum dan Perumahan Rakyat [Minister for Public Works and Human Settlements])

[2] Kementerian Kehutanan dan Lingkungan Hidup [Ministry of Forestry and the Environment] 2013 Status Lingkungan Hidup Indonesia Tahun 2013 [Indonesia Environmental Status 2013] (Jakarta: Kementerian Kehutanan dan Lingkungan Hidup [Ministry of Forestry and the Environment])

[3] Muhtadi A, Cordova M R and Yonvitner 2014 Buku Penunut Praktikum Ekologi Perairan [Aquatic Ecology: A Practical Guide] (Bogor: IPB Press)

[4] Muhtadi A, Dhuha O R, Desrta, Siregar T and Muammar 2017 Kondisi habitat dan keragaman nektorn di hulu DAS Wampu, Kabupaten Langkat, Provinsi Sumatera Utara [Habitat conditions and diversity of necton in catchment area of Wampu River, Langkat Regency, North Sumatra Province] Depik 6 pp 90-9

[5] Desrta, Muhtadi A, Tamba I S, Ariyanti J and Sibagariang R D 2018 Community structure of necton in the upstream of Wampu Watershed, North Sumatra, Indonesia Biodiversitas 19 pp 1366-74

[6] North Sumatera Province Peraturan Daerah No. 2 Tahun 2017 Tentang Rencana Tata Ruang dan Wilayah Provinsi Sumatera Utara tahun 2017-2037 [Regulations in the province of North Sumatra No. 2, 2017 about North Sumatra Province Spatial Plan for 2017-2037] (Medan: North Sumatra Province Regulation Registration Number: 2/67/2017)

[7] PT. North Sumatera Hydro Energy 2016 Addendum Environmental Impact Assessment Plan for Development of Water Power Plant of 500 Mw to 510 Mw (4 X 127.5 Mw) And Quarry Location Change in Tapanuli District, South - North Sumatera Province (North Sumatera: PT. North Sumatera Hydro Energy)

[8] Peraturan Pemerintah No. 82 tahun 2001 tentang Pengendalian Pencemaran Perairan (Government regulation No. 82 of 2001 about Controlling aquatic pollutions)

[9] Yule C M and Yong H S 2004 Freshwater Invertebrates of the Malaysian Region (Kuala Lumpur: Academy of Sciences Malaysia)

[10] Blakely T J, Eikaas H and Harding J S 2014 The Singscore: a macroinvertebrate biotic index for assessing the health of Singapore’s streams and canals Raffles Bulletin of Zoology 62 pp 540-8

[11] Mustow S E 2002 Biological Monitoring of Rivers in Thailand: use and adaptation of the BMWP score Hydrobiologia 479 pp 191-229

[12] Mihov S and Hristov I 2011 River Ecology (Vienna: WWF Danube Carpathian Program WWF-DCPO)

[13] Gordon N D, McMahon Ta, Finlayson B L, Gippet G J and Nathan R J 2004 Stream hydrology: an introduction for ecologists - 2nd ed (Chichester: John Wiley & Sons Ltd)

[14] Odum E P 1996 Dasar Ekologi edisi ketiga [Fundamentals of Ecology 3ed] Translator: Samingan (Yogyakarta: UGM Press)

[15] Haryono 2004 The cyprinidae tribe fish community in the waters around Bukit Batikap in the Muller Mountains region of Central Kalimantan Jurnal Iktiologi Indonesia 4 (2) pp 79-84
[16] Fatmawati P, Soegianto A and Hariyanto S 2018 Benthic Macroinvertebrates Diversity as Bioindicator of Water Quality of Some Rivers in East Kalimantan, Indonesia International Journal of Ecology 5129421

[17] Kartikasari D, Retmaningdyah C and Arisoesilaningsih E 2013 Application of Water Quality and Ecology Indices of Benthic Macroinvertebrate to Evaluate Water Quality of Tertiary Irrigation in Malang District The Journal of Tropical Life Science 3 (3) pp 193-201

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