Research Article

Evaluation of water quality in the swamp river border using water quality index

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Abstract: As a source of minerals, water must be continuously maintained, including in term of its quality. Meanwhile, swamps are wetlands that have the potential to experience a decline in water quality. The presence of river borders in swamps has been known to maintain their water quality. Vegetation cover of the river border is established through restoration activities in which it is expected, directly and indirectly, to improve water quality. This study aimed to investigate the water quality in swamp using the Water Quality Index (WQI). Surveys were carried out and samples were collected to determine the effect of restoration on river border in swamps. Samples were collected severally, namely prior to restoration (T0), first year (T1), third year (T3) and fourth year (T4) after restoration. The parameters for water quality of T0 and T1 include pH, DO, BOD, TDS, turbidity and nitrate, while for T3 and T4 include: pH, DO, BOD, TDS, temperature, phosphate, E. coli and nitrate. The findings indicated that the WQI of the swamp prior to restoration was greater than that at the first year of restoration due to the process of land clearing. Meanwhile, the WQI at the third year has improved compared to before the restoration and land clearing phase. It suggests that the presence of vegetation on river border is able to improve the water quality. At the fourth year, a fire in the upstream reached the area adjacent to the study site. It led to a decline in surface water quality and affected the water quality index. Furthermore, the abundance of aquatic biota was indicated by two taxa of zooplankton in the third year of restoration while none of them was identified in the fourth year. In overall, restoration activities on the river border improve the quality of water in swamps in a sustainable manner.

Keywords: restoration, swamp, vegetation, water quality

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Introduction

The quality of water is vital, considering the function of water as the source of all life. In general, water quality index reveals the quality of the environment around water bodies, including in peat swamps. Rasidah et al., (2017) found that despite the water in peatland has pH values in the range from 3 to 4, yellowish-brown color and high levels of organic, iron and manganese, it has the potential as raw water with certain processes. Meanwhile, peatland is a life support system (Irma et al., 2017) which sustainability must be prevailed. In fact, any damage may lead to a decline in water quality. Hence, potential damage must be overcome immediately considering the essential role of peat swamps for ecosystems and biodiversity (Sudrajat and Subekti, 2019).

River border is the parts located on the banks of the river in which its existence indicates the health of a river. According to Fachrudin and Lubis (2016), river border is capable of maintaining water quality. Similarly, Maryono (2009) suggested the direct influence of river border on the river including its physical, ecological, hydraulic and morphological changes. In general, a healthy river border is indicated by the condition of the vegetation cover. It is claimed
to inhibit any possible contamination in the river. Moreover, vegetation on the river border also has an inhibiting effect on sedimentation and erosion, as well as a positive influence on aquatic organisms living in mud-free water (Jones et al., 1999).

The Water Quality Index (WQI) has been frequently employed for assessing water quality in swamps. This index expresses the water quality of rivers, which is very useful in devising any improvement plans (Bordalo et al., 2006). Nevertheless, the changes in vegetation covers on swamps are known to affect the values of WQI, both directly and indirectly. An effort to improve the swamp ecosystem is through restoration. It has been highlighted to improve an existing ecosystem (Menberu et al., 2017). Furthermore, revegetation is an activity of restoration plans (Waluyo and Nurlia, 2017). According to Anggana and Ahmadi (2018), such activity can involve local plants that is very useful for the restoration of swamps, particularly in river borders. This study aimed to investigate the values of WQI in swamps and compared the values after and before restoration.

Materials and Methods
P5 River or Sungai P5 is located in Pawalutan village, Banjang subdistrict, North Hulu Sungai Regency, South Kalimantan, Indonesia. Restoration has been done in this area, approximately 8.8 km in length and 5-7 m in width. Several native plants are used, including Ketapang (Terminalia catappa L.), Sengon (Paraserianthes falcataria (L) Nielsen, Trembesi (Samanea saman), Meranti Rawa (Shorea balangeran), Galam (Melaleuca leucadendron) and Jelutung Rawa (Dyera costulata) (Anggana and Ahmadi, 2018). The study site is specified in Figure 1.

In the present study, the survey method has been selected and samples of surface water have been collected to determine the effect of the restoration on the river border of swamp. Samples of surface water were collected prior to the restoration activities (T0), and first year (T1), third year (T3) and fourth year (T4) after restoration. Several parameters were examined for the water quality of T0 and T1, namely: pH, DO (Dissolved Oxygen), BOD (Biochemical oxygen demand), TDS (Total dissolved solids), turbidity and nitrate. Meanwhile, parameters for T3 and T4 include pH, DO, BOD, TDS, temperature, phosphate, E. coli and nitrate. In addition to the assessment on the water quality, the abundance of aquatic biota on T3 and T4 was also examined, particularly on the abundance of Plankton and Benthos.
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**Water Quality Index**

The formula used to determine the WQI is based on the National Sanitation Foundation Water Quality Index (NSF-WQI) that can be noticed in the following expression:

\[ \text{NSF-WQI} = \sum_{i=0}^{n} W_i \times L_i \]  

where:  
\( W_i \) = the weight,  
\( L_i \) = the sub-index obtained from curves.

The results of water quality data analysis is further used to determine the criteria for each sample as presented in Table 1.

Table 1. Criteria of Water Quality Index

| No | NSF-WQI Score | Criteria   |
|----|---------------|------------|
| 1. | 0 – 25        | Very bad   |
| 2. | 26 – 50       | Bad        |
| 3. | 51 – 70       | Medium     |
| 4. | 71 – 90       | Good       |
| 5. | 91 – 100      | Excellent  |

Source: Water Research Center, 2019

**Level of biodiversity**

In this study to determine species diversity using the Shannon-Weaver Diversity Index \( (H') \) according to Gagan et al. (2018). The equation as follows:

\[ H' = -\sum [P_i \ln P_i] \quad P = \frac{N_i}{N} \]

where:  
\( H' \) = Shannon Index  
\( N_i \) = Number of individuals  
\( N \) = Number of all types

**Results and Discussion**

**Water Quality Index**

The analysis of the water quality index shows the changes in the quality of surface water in the study site. The results of data analysis are presented in Table 2. Based on the result, the quality of surface water prior to the restoration (T0) and in the first year of restoration (T1) have the same criteria, despite their different index values. T0 has a higher index than T1 allegedly due to the preparation on the river border for the restoration process. It leads to the higher content of both BOD and TDS. Nirtha (2014) suggests such preparation possibly causes erosion that eventually affects the TDS in water bodies. Based on the results of laboratory analysis, it can be seen an increase in the value of TDS caused by erosion on the banks of the river, in this case an increase in the value of TDS from 32 mg/L to 83 mg/L. Likewise, Salim and Dharmawan (2017) affirm that the increase in TDS is due to the addition of dissolved materials that influence the turbidity of the waters and inhibits light penetration, leading to the higher content of BOD. Syofyan (2019) claims that BOD is the oxygen needed by microorganisms to decompose organic matters; thus, the increase in TDS will affect aquatic life or water quality. The same results were also found in the water quality index of T3 and T4. Based on the results of the analysis, T3 has a higher index than T4. The values are 55.235 and 48.133, respectively, in which T3 is classified Medium while T4 is classified Bad. Based on the results of the data analysis, the WQI of T3 is higher than the index of T0 and T1. It shows that restoration activities on the river border could improve water quality. Land management and appropriate land-use have a positive effect on water quality (Ahmad, 2019) reaffirm the significance of vegetation cover on the amount of suspended solids in water bodies. The presence of plants around water bodies plays an important role in aquatic ecosystems (Ayu et al., 2017). Table 2 shows the decline in water quality of the fourth year after the restoration (T4) compared to the previous year (T3). The survey in the field revealed that this declined quality was allegedly caused by a fire in the upstream adjacent to the study site. It adversely impacted the surface water quality, leading to the lower WQI compared to the previous year. The results of water quality assessment disclose the decrease of several parameters, including pH, temperature, nitrate and TDS. It has been reported by Wasis et al. (2019) that fire can be devastating for the hydrological conditions of the land. Fire causes vegetation, litter and microorganisms to disappear so that it will damage the soil structure. Damage to the structure will hamper hydrological processes such as interception, evapotranspiration, infiltration and runoff (Depari et al., 2009).

**Abundance of aquatic biota**

The abundance of aquatic biota has been observed thoroughly after the restoration activities. This observation is substantial to signify the necessity of water quality as a source of a variety of life both for humans, flora and fauna (Rehnuma et al., 2016). The observation results of WQI Analysis on T3 and T4 are presented in Table 2.
### Table 2. Result of WQI Analysis on T0, T1, T3 and T4.

| No | Parameter (unit) | T0     |     |     | T1     |     |     | T3     |     |     | T4     |     |     |     |
|----|-----------------|--------|-----|-----|--------|-----|-----|--------|-----|-----|--------|-----|-----|-----|
|    |                 | TV     | Qe  | WF  | Calc   | TV  | Qe  | WF  | Calc   | TV  | Qe  | WF  | Calc   | TV  | Qe  | WF  | Calc   |
| 1  | DO (mg/L)       | 4.21   | 3.5 | 0.23 | 0.805  | 5.52| 4.25| 0.23 | 0.978  | 6.300| 5.060| 0.180| 0.911  | 6.410| 5.125| 0.180| 0.923  |
| 2  | pH              | 5.83   | 51.125| 0.17 | 8.691  | 5.21| 31.75| 0.17 | 5.398  | 5.780| 47.250| 0.120| 5.670  | 4.620| 18.000| 0.120| 2.160  |
| 3  | BOD (mg/L)      | 5.21   | 53.125| 0.17 | 9.031  | 13.25| 24.125| 0.17 | 4.101  | 16.500| 17.500| 0.120| 2.100  | 16.500| 17.500| 0.120| 2.100  |
| 4  | Nitrate (mg/L)  | 0.042  | 98  | 0.16 | 15.680 | 0.6 | 95.5 | 0.16 | 15.280 | 0.189| 97.250| 0.110| 2.160  | 16.500| 17.500| 0.120| 2.100  |
| 5  | Turbidity (NTU) | 52     | 37.75| 0.14 | 5.285  | 70  | 28  | 0.14 | 3.920  | -    | -    | -    | -    | -    | -    | -    | -    |
| 6  | TDS (mg/L)      | 38     | 87.31| 0.13 | 11.350 | 82  | 86.72| 0.13 | 11.274 | 40.000| 88.120| 0.080| 7.050  | 408.000| 45.820| 0.080| 3.666  |
| 7  | Temperature (°C) | -     | -   | -   | -     | -    | -   | -    | -     | 27.700| 12.180| 0.110| 1.340  | 29.700| 10.625| 0.110| 1.169  |
| 8  | E. Coli (CFU/100ml) | - | - | - | - | - | - | - | 0.000 | 98.000| 0.170| 16.660| 0.000 | 98.000| 0.170| 16.660 |
| 9  | Phosphate (mg/L) | -     | -   | -   | -     | -    | -   | -    | -     | 0.034 | 98.250| 0.110| 10.808 | 0.003 | 99.000| 0.110| 10.890 |
|    | NSF-WQI Score   | 50.843 | 40.950| 55.235| 48.133 |

**Criteria:**
- **Bad**
- **Medium**
- **Good**

Remark: TQ = Tested Value, laboratory analysis result; QV = Q Value, Modified values based on Q value recommendations from Water Research Center (2019); WF = Weight Factor, modification of weights is based on recommended parameter values from Water Research Center (2019); and Calc = Calculation, water quality value per parameter.
Table 3. Identification of phytoplankton, zooplankton, and benthos.

| No | Phylum         | Genera                  | Year | T3 | T4 |
|----|----------------|-------------------------|------|----|----|
|    | Phytoplankton  |                         |      |    |    |
| 1  | Cyanophyta     | Oscillatoria            | 24   | 8  |    |
|    |                | Aphanoizomenon          | 8    |    |    |
|    |                | Spirulina               | 8    |    |    |
|    |                | Anabaenopsis            | 8    |    |    |
|    |                | Colothrix               | 8    |    |    |
| 2  | Chlorophyta    | Gonatozygan             | 100  | 24 | 16 |
|    |                | Ankistrodesmus spiralis | 24   |    |    |
|    |                | Binuclearia w           | 16   |    |    |
|    |                | Sphaerostus             |      |    |    |
|    |                | Schroctery              | 24   |    |    |
|    |                | Spirogyra               | 16   |    |    |
| 3  | Chrysophyta    | Rhizosolenia imbicata   | 12   |    |    |
|    |                | Streptotheca            | 12   | 24 |    |
|    |                | Synedra                 | 28   | 8  |    |
|    |                | Thallasiossira sp       | 32   | 8  |    |
| 4  | Freshwater diatom | Eunotia teetrodon   | 40   |    |    |

Phytoplankton, zooplankton and benthos on the third year (T3) and fourth year (T4) after the restoration are presented in Table 3. The identification reveals the changes in the abundance of aquatic biota in the third year (T3) and fourth year (T4) after the restoration, in which a fire occurred in the fourth year. The abundance of phytoplankton in T3 is 260 cells/liter with Evenness index ($E$) of 2.7374, and a total of nine taxa. Meanwhile, in T4, the abundance is 96 cells/liter, with $E$ of 1.5397, and a total of five taxa. These changes are accompanied by changes in the abundance of zooplankton. The identification process reveals only two taxa of zooplankton in T4, and none on the subsequent year. The same phenomenon is also observed in the abundance of benthos. The fire adversely affected the abundance of benthos as indicated by none of them were found after the fire occurred or during the fourth year after the restoration. Meanwhile, two taxa were still observed within the third year after the restoration (T3). Specifically, the abundance of benthos in T3 is 176/m² and $E$ of 0.8113, with a total of two taxa.
It suggests that fire has a huge destructive impact, including the deterioration of water quality and the reduction rate in the abundance of phytoplankton, zooplankton and benthos. It has been argued by Wassis et al. (2019) that forest fires cause tremendous damage to the ecosystems, both abiotic and biotic.

**Conclusion**

The assessment on the water quality of swamps before the restoration reveals that it has a higher water quality index (WQI) than the condition in the first year of the restoration due to the preparation phase or land clearing process. Furthermore, the value of WQI in the third year after the initiation of restoration activities is higher than the values obtained before and in the first year of the restoration. It suggests the vegetation cover on the river border can improve the water quality. In the fourth year after the restoration, a fire occurred in the upstream of the river adjacent to the study site. It caused a decline in surface water quality, leading to a lower value of WQI compared to previous observed years. Restoration activities are a constructive effort to improve the water quality, one of which is through the revegetation of native plants. Nevertheless, maintenance and monitoring on a regular basis are required to ensure the sustainable functions of the river border.

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**References**

Abidin, F., Millang, S. and Anyad, U. 2019. River water quality in various types of land in the sub-watersheds in the Latuppa watershed. *Jurnal Hutan dan Masyarakat* 11(1): 59–72 (in Indonesian).

Ahmad, M. 2019. The effect of landuse on the border of the middle Progo River on the water quality and surface runoff. *Jurnal Bumi Indonesia* 8(2): 1–16 (in Indonesian).

Anggana, A.F. and Ahmadi, R.A. 2018. Restoration of the P5 river border, South Kalimantan. *Proceedings of The UMS IX 2018 National Geography Seminar* 525–534. Surakarta (in Indonesian).

Ayu, I.G., Pradnya, A. and Kurniawan, R. 2017. The Composition of water plant and riparian plant in Lake Sentani, Papua Province. *Oceanoledi dan Limnologi di Indonesia* 2(2): 33–48 (in Indonesian).

Bordalo, A.A., Teixeira, Â.E.R. and Wiebe, Â.W.J. 2006. A water quality index applied to an international shared river basin: the case of the Douro River. *Environmental Management* 38: 910–920, doi: 10.1007/s00267-004-0037-6.

Depari, E.K., Tampang, A, Restu, A.B., Surnayanti, Adinugroho, S. 2009. The Effect of Forest Fire on Hydrology Function. Silviculture Tropic Mayor. Postgraduate. Bogor Agriculture University.

Fachrudin, H.T. and Lubis, M.D. 2016. Planning for riverside area as a water tourism destination to improve quality of life local residents, case study: Batuan-Sikambing River, Medan, Indonesia. *Procedia - Social and Behavioral Sciences* 234: 434-441, doi:10.1016/j.sbspro.2016.10.261.

Gagan, M., Laura, G., Avinash, K. and Machel, J. 2018. Hydrochemical characteristics and planktonic composition assessment of River Henwal in Himalayan Region of Uttarakhand using CPI, Simpson’s and Shannon -Weaver Index. *Journal of Chemical and Pharmaceutical Sciences* 11(1): 122–130, doi: 10.30558/jcps.20181101023.

Irama, W., Gunawan, T. and Suratman. 2017. Peatland Ecosystem Management with Maintaining Vegetation Biodiversity in the Downstream Kampar Riau Sumatra Watershed. *Proceedings of the UMS National Geography Seminar* 539–549 (in Indonesian).

Jones, E.B.D., Helfman, G.S., Harper, J.O. and Bolstad, P.V. 1999. The effects of riparian forest removal on fish assemblages in Southern Appalachian streams. *Conservation Biology* 13(6): 1454-1465.

Maryono, A. 2009. The study of river border (a case study of rivers in the Special Province of Yogyakarta). *Dinamika Teknik Sipil* 9(1): 56-66 (in Indonesian).

Menberu, M.W., Marttia, H., Tahvanainen, T., Kotiaho, J.S., Hokkanen, R., Klovve, B. and Ronkanen, A.K. 2017. Changes in pore water quality after Peatland restoration: Assessment of a large-scale, replicated before-after- control-impact study in Finland. *Water Resources Research* 53: 8327–8343, doi: 10.1002/2017WR020630.

Nirtha, I. 2014. The study of erosion hazard level and effect on the water quality (TSS and TDS) of the Sejorong Watershed, Sekongkang District, West Sumbawa Regency, West Nusa Tenggara Province. *EnviroSciences* 10: 27-32 (in Indonesian).

Rasidah, Lapanporo, B.P. and Nurchasanah. 2017. The improvement of peat soil water quality using the electrocoagulation method. *Jurnal Prisma Fisika* V(2): 77–82 (in Indonesian).

Rehnuma, M., Islam, M.S., Meghla, N.T. and Kabir, M.H. 2016. Investigation of water quality from Bangshi River at Tangail in Bangladesh. *Journal of Science and Technology* 6(1&2): 153–160.

Salim, A.G. and Dharmawan, I.W.S. 2017. Potpourri. Bogor: Forda Press (in Indonesian).

Sudrajat, A.S.E. and Subekti, S. 2019. Peat ecosystem management as an effort to mitigate climate change in South Kalimantan Province. *Jurnal Planalogi* 16(2): 219–237 (in Indonesian).

Syofyan, E.R. 2019. Community participation in the context of controlling river pollution. *Jurnal Ilmiah Poli Rekayasa* 14(2): 39–48 (in Indonesian).

Waluyo, E.A. and Nurlia, A. 2017. Potential...
Development of Coffee Liberica (Coffea liberica) Agroforestry Patterns and Marketing Prospect to Support Peatland Restoration in South Sumatra (Learning From the District of Tanjung Jabung Barat, Jambi Province). *National Seminar Proceeding of Lahan Suboptimal 2017* (pp. 978–979). Palembang: Universitas Sriwijaya (*in Indonesian*).

Wasis, B., Saharjo, B.H. and Waldi, R.D. 2019. The Impact of forest fires on the flora and nature of mineral soils in the forest area of Pelalawan Regency, Riau Province. *Jurnal Silvikultur Tropika* 10(1): 40–44 (*in Indonesian*).

Water Research Center. 2019. Monitoring the Quality of Surface Waters: Calculating NSF Water Quality Index (WQI). Water Research Center. http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters.