Comparison of dissolved organic carbon and nutrients content in Papua peatland

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Abstract. Indonesia’s peatlands degrade due to land conversion and land development. Peatland conversion affects nutrient content in peat soil and peat water, including dissolved organic carbon (DOC). Research on the comparison of DOC and nutrient content was conducted in Papua peatland. It was carried out at Kaliki and Marga Mulia in Merauke, and also at Khanami and Yame in Mappi. This research aimed to determine DOC, soil, and water nutrients, then compare them among peatlands in Merauke and Mappi. At each location, three replications of peat water and peat soil were sampled by digging to a depth of 20 cm. The peat water was estimated for DOC concentration and nutrients, but peat soil was analyzed for nutrients only. The DOC concentration at Yame was the highest among the sites, followed by Khanami, Marga Mulia, and Kaliki. Soil carbon stored was estimated highest at Khanami, followed by Kaliki, Yame, and Marga Mulia. It was concluded that the DOC and soil carbon stored were higher in Mappi peatland than in Merauke peatland because it was still preserved by the community and no peatland conversion in Mappi.

Keywords: DOC, nutrients, Papua, peatland, soil carbon.

1. Introduction
The Indonesian government acknowledges 149,056 km2 of peatland on its three major islands, with Kalimantan accounting for 28-32 %, Sumatra accounting for 34-43 %, and Papua accounting for 25-38 % [1]. Nowadays, primary peat forests in Kalimantan and Sumatra remain about 7%, but they are still large in Papua [2]. The peat results from dead plant parts accumulation and its thickness are deeper than 50 cm [3]. Peatlands provide habitats for plants and animals, forest products, and ecosystem services. Peatlands alteration for plantation and other utilization disturb their ecosystems [4].

Dissolved organic carbon (DOC) leaching through water including surface and groundwater comes from peat soil [5, 6]. The DOC is important in the peatland carbon cycle because it shows a part of the carbon released from peat and plant parts decomposition [7, 8]. The DOC is an organic carbon that could pass through a filter in size 0.25 μm, could be transported, mineralized, and then leached through both groundwater and surface water, and also part of carbon balance [9, 10]. The nutrient of the water and its quality were affected by DOC [11,12].

Organic carbon is stored in peat soil [13]. The carbon (C) and nitrogen (N) contents may be determined using C/N. Mineral nutrients of peatlands are low at the center and high at the edge of the peat dome. They are calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), and phosphorous (P). Peat soil provides them for plant growth. Thus, this study aims to determine DOC, soil, and water nutrients, then compare them among peatlands in Merauke and Mappi, Papua Province.
2. Study Sites and Methods

2.1. Sampling sites

These sites were carried out in Merauke and Mappi, in Papua Province. The sampling sites in Merauke were Kaliki Village at Kurik District and Marga Mulia Village at Semangga District. According to the previous research about plant diversity in these sites, Kaliki was dominated by Beilschmiedia sp., Carallia brachiate (Lour.) Merr., and Kibara coriacea (Blume) Hook. f. & A. Thomps, whereas Marga Mulia was dominated by Melaleuca leucadendra (L.) L. However, Khanami was dominated by Semecarpus forstenii Blume, Archidendron clypearia (Jack) I.C. Nielsen, and Campnosperma auriculatum (Blume) Hook.f., but Yame was dominated by Calophyllum euryphyllum Lauterb, Diospyros topsioides King & Gamble, and Syzygium effusum (A.Gray) Müll. Stuttg.

Figure 1 depicts the sample plot's position in Merauke at Kaliki and Marga Mulia, while Figure 2 shows the sampling plot's location in Khanami and Yame.

![Figure 1](image1.png)

Figure 1. Plot location of sampling at Kaliki and Marga Mulia in Merauke.

2.2. Peat soil analysis

Peat soil was sampled in one subplot of the plot center and four subplots of the plot corners at the sampling sites. The peat soil was sampled in a depth of 20 cm, kept in the plastic, weighed, and dried in the oven at 60°C until the weight is constant. The samples were prepared for chemical analysis were homogenized by an electric grinder and analyzed for nitrogen and carbon content using an automatic CN analyzer (Yanaco 1000, Japan), while for P, K, Ca, Mg analysis, and Na, samples were prepared by wet digestion method using a mixture of H$_2$SO$_4$, HNO$_3$, and HCl. Furthermore, the extract from the digestion was used to measure P content with a UV-Vis (UV 1240) spectrophotometer, Ca and Mg with an atomic absorption spectrophotometer, while K and Na content was measured with a flame photometer (Shimadzu AA-6800).
3. Results and Discussion

3.1. Dissolved organic carbon measurements

The results of dissolved organic carbon (DOC) concentration measurements were conducted in study sites shown in Table 1.

Table 1. Results of dissolved organic carbon concentration in Merauke and Mappi

| Sites                      | DOC concentration (mgL⁻¹± SE) |
|----------------------------|-------------------------------|
| Kaliki Village, Merauke    | 6.23 ± 0.36                   |
| Marga Mulia Village, Merauke | 6.44 ± 0.09                  |
| Khanami Village, Mappi     | 15.29 ± 0.90                  |
| Yame Village, Mappi        | 38.19 ± 0.68                  |

The DOC concentrations in Mappi were higher than those in Merauke. The highest DOC concentration was measured at Yame Village in Mappi, whereas the lowest DOC concentration was measured at Kaliki Village in Merauke. The highest DOC concentration in Yame Village, followed by Khanami Village in Mappi was due to the condition of peatlands in Mappi and Merauke. Mappi's peatland was in better condition than that of Merauke. It was related to plant diversity, and communities in the peat forest make advantage of it. The plant diversity in Mappi peatland was greater than that in Merauke peatlands. Generally, the people living there used the plants for the needs of life, medicine, houses, shipbuilding, and religious rituals [14]. The same result was also shown in pristine peat swamp forest in Central Kalimantan during 2010-2013. This peat forest is still preserved and the plant diversity is better than other peat forests that occurred forest fires several times. The measurement of DOC concentration in the pristine site was higher than that at the burnt site [15].

The DOC concentration at Kaliki Village was the lowest among the sites, followed by Marga Mulia Village in Merauke. These results were due to organic matter decomposition reduction of the site. Most of the Kaliki people burn grass on the forest floor [14]. Burning forests can damage the ecosystem of
the forest. Consequently, the biological and physical properties of the land surface have changed. These also affect many biological and hydrological processes. The soil at this site had become charcoals, and much carbon dioxide (CO₂) was emitted into the atmosphere. Another reason was due to DOC dilution. It was diluted through water flow to the river, so its concentration became low. The reduction of soil organic matter would decrease the production of DOC, and much water on relatively flat peat at the burnt site would increase the dilution of DOC. People in Marga Mulia Village had cleared the peatland by cutting the vegetation and burning the lands to open rice fields and other plantations surrounding there.

Previous studies indicated that the fires significantly decreased the DOC concentration at the spruce forest and peat swamp forest in 2003 and 2012, respectively. The DOC concentration decreased about one month after the fire in the spruce forest because the production of black carbon (charcoal) from the burned soil would affect the DOC dynamics on the land surface, and the black carbon from the burnt soil likely adsorbed DOC had contributed to the decrease of the DOC concentration in the leached water from the soil layer [16]. The measurement of DOC concentration in 2012 at peat swamp forests of Central Kalimantan showed that DOC concentration was lower at the burnt peat swamp forest than at the pristine peat swamp forest. It indicated that the effect of fires decreased the DOC concentrations [17].

3.2. Nutrient content in peat water and peat soil

The measurement of nutrients in peat water consists of P (phosphorus), Magnesium (Mg), Calcium (Ca), Sodium (Na), and Potassium (K). The results are shown in Figure 3. Marga Mulia Village in Merauke has the greatest levels of nutrients (P, Mg, Ca, Na, and K). These findings demonstrated that land-use change has an impact on the nitrogen content of peatland. Only Melaleuca leucadendra (L.) L dominated the peatland in Marga Mulia Village [14]. Besides that, there was rice fields and other plantations such as fruit and vegetables. According to the head of Marga Mulia Village, primarily people who live surrounding there came from Java Island as a farmer. They cleared the land for their daily needs and economic enhancement. The land was opened by cutting the vegetation, burning the land, and building the irrigation system. They also added some fertilizer, including nutrients for the soil, to increase land fertilization. The fertilizer has been absorbed into the soil via the soil pore. They are washed and dissolved in the water flow during the rainy season.

The measurement of nutrients in peat soil consists of P (phosphorus), Magnesium (Mg), Calcium (Ca), Sodium (Na), and Potassium (K). The results are shown in Figure 4. C/N was also measured in peat soil, and the results were shown in Table 2. K is the highest nutrient among the sites compared to other nutrients. Yame Village in Mappi had the highest K measurement. It indicates that the alkali cation content of K in the peat soil was substantially greater than the alkali cation content of P, Mg, Ca, and Na at each site, and that the alkali cation content of K in the peat soil was higher at the Yame site than at the other locations. The thicker the peat, the lower the alkali cations content [18].

The nutrient content in peat water was higher than that in peat soil. Perhaps it is because of the period time of sampling. This sampling was conducted in November 2018 during the rainy season. During this season, the nutrients are washed by the rainwater flow and dissolved before it flows to the canal or river. The results of Carbon/Nitrogen or C/N were shown in Table 2.

| Sites                        | C/N ± SE  |
|------------------------------|-----------|
| Kaliki Village, Merauke      | 25.37 ± 0.97 |
| Marga Mulia Village, Merauke | 20.35 ± 0.94 |
| Khanami Village, Mappi       | 26.89 ± 1.65 |
| Yame Village, Mappi          | 24.46 ± 2.10 |
The results of C/N at each site showed that peatland in Khanami Village has the highest carbon stored, followed by Kaliki Village, Yame Village, and Marga Mulia Village. It also showed that carbon stored in all sites was high. The carbon stored in the various peatland types, including drained and burnt peatland and pristine peatlands in Kalimantan and Sumatra, showed that the carbon was the highest among other significant nutrients such as nitrogen and phosphorous calcium, magnesium, potassium,
and sodium [19]. Marga Mulia site stored the lowest carbon compared to other sites. Probably, it was related to the land conversion on this site. People in this village have cleared the lands by burning, then the carbon stored in the soil was emitted to the atmosphere as CO2, decreasing the soil carbon stored at this site.

4. Conclusion
DOC concentration was higher at the Yame Village in Mappi than other sites, and DOC concentration was lower at the Kaliki Village in the Merauke area than other sites. The highest soil carbon was estimated at Khanami Village in Mappi, whereas the lowest was measured at Marga Mulia Village in Merauke. It could be concluded that the DOC and soil carbon stored were higher in Mappi than in Merauke due to the conditions of Mappi and Merauke peatlands, including fires and land conversion, and their vegetations.

Nutrient content in the peat water and peat soil were also measured at each study site. The highest nutrients, including potassium, magnesium, phosphorus, calcium, and sodium in the peat water, were measured at Marga Mulia Village in Merauke. Potassium is the highest nutrient in the peat soil compared to other nutrients at each study site. The highest measurement of potassium in the peat soil was shown at Yame Village in Mappi.

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