Community Structure of Plankton at Central Kalimantan Peat Swamp Area

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Abstract. Land opening activities for agricultural purposes in Central Kalimantan peat swamp area lead the change of water quality. There will be a different pattern of hydrology between wet and dry season that will influence the existence of plankton. The aim of the study was to understand the plankton community structure of Central Kalimantan peat swamp in two different seasons, the wet and dry season. The research was carried out by taking samples for water quality and plankton observation in eight sites. The data analysis consisted of spatial clustering analysis based on Canberra Index of water quality, diversity index, and PCA of plankton community and water quality relationship. The result showed that there were separately clustered channel waters between natural and artificial; with 56 and 36 species of phytoplankton, and zooplankton, respectively. The numbers of species were higher in wet season than in dry season. The most different conditions between the seasons were water current velocity and depth of waters. The plankton communities were highly correlated to depth, conductivity, and water current condition.

1. Introduction
Peat areas of Indonesia are located in East Kalimantan, South Kalimantan, Central Kalimantan, and eastern part of Sumatera. The peat are potentially utilize as an energy source (as coal), agricultural and plantation area, forest area, ecological buffer, and industrial raw materials. There is 1 ha of land opening activities for agricultural purposes in Central Kalimantan, and there are many canals constructed in the area. On the other hand, the wetlands that is widely covered of Central Kalimantan has many big rivers flow within. Some of those are connected to surrounded rivers or connected to each other.

Aquatic ecosystem in peat swamp area provides unique condition and water quality, related to the unique condition of its peat soils. The wet lands may be dominated by precipitation [1]; precipitation serves as sole source of water for some wetlands. As in Central Kalimantan, low land tropical peat lands are usually dome-shape and the only input of water and nutrients to them is from precipitation [2]. The water is stored in the dome of peat soil, and generally have no significant inflows or outflows [1]. Therefore, there is a change of hydrological pattern as consequence of land opening activity. This leads less resistance of water in the dome of peat soil, flowing through out of system.

Drainage of land opening, logging as part of raw material industry, and forest burning causes severe damage to the peat domes of peat lands at Central Kalimantan. The chemical properties of peat change upon oxidation, especially after burning. The following effects may be expected: (a) increase...
in acidity, owing to oxidation of pyrite in deeper mineral layers or leakage of organic acids from the peat; (b) increase in solute concentrations, resulting in release of nutrients following decomposition of the peat [3]. It is shown that the more open land area, the less nutrient contained in the water [4].

The low pH and low load capacity of peat soil of nutrients leads low pH and low nutrients of peat water. Those water quality influence nutrients utilization by phytoplankton. Furthermore, it influence zooplankton as predator of phytoplankton. Phytoplankton and zooplankton are cosmopolite in different types of aquatic ecosystem. However, each of species has specific requirement of livelihood conditions, such as nutrients and water quality. Peat swamp as one of unique aquatic ecosystem of wet lands, might be has a potential specific organisms, especially plankton.

However, most of research at peat swamp area were related to study on big flora and fauna living in, and its management [5-10]. There are still limited information about water quality and plankton communities in this ecosystem. Accordingly, the study was emphasized on plankton biodiversity of peat swamp in some location related to nutrients and water quality.

2. Methods

2.1 Sample collection and observation

The study was carried out in eight locations, each with two sampling sites (Figure 1 and Table 1). Those locations represented natural flow, natural stagnant waters, and artificial flows. There were two periods of sampling that based on season, dry and rainy (wet) season. The identification of plankton was done following to some references [11-14]. The water quality analysis and plankton density counting was refer to APHA [15].

![Figure 1. Sampling locations for plankton and water quality at Central Kalimantan peat swamp](image)

Water samples were taken by 3L van Dorn water sampler at each sampling site of each season. There were in situ observations (temperature, pH, water transparency, velocity current) and laboratory analysis (nutrients) in collecting water quality data. Plankton samples were taken by filtering 10 L of water with 35 µm mesh sized plankton net, and preserved with Lugol’s solution 1%. Furthermore, the specimens were observed in Sedgwick Rafter Cell (SRC) under light microscope for identification.
Table 1. Sampling location of observation at Central Kalimantan peat swamp

| Sampling location       | Code of location | Explanation                      |
|-------------------------|------------------|----------------------------------|
| St.1 (Upstream of Sabangau) | SHU              | Natural flow                     |
| St.2 (Downstream of Sabangau) | SHI              | Natural-Artificial flow          |
| St.3 (Mangkutup)        | MKT              | Lake with natural flow           |
| St.4 (Mentangai)        | MTG              | Artificial flow                  |
| St.5 (Arai)             | SAR              | Natural flow                     |
| St.6 (Jaya)             | SJY              | Artificial flow                  |
| St.7 (Keruing)          | KER              | Lake with natural flow           |
| St.8 (Bulan)            | SBL              | Natural flow                     |

2.2 Data analysis

The biodiversity of plankton was analysed using several index, i.e. Shannon-Wiener Diversity Index (H'), Index of Evenness (E), and Simpson Dominance Index (C)[16, 17]. Furthermore, there were cluster analysis based on Canberra Index[18] in order to make spatial grouping using water quality information, and PCA (Principal Component Analysis[19] as approach to understand the relationship between plankton community and water quality.

3. Result and Discussion

The water quality of the two seasons of each station showed various performances (Table 1). It was indicated that some of parameters were relatively constant, such as DO and pH. Furthermore, water velocity and water depth were little higher in wet season. Meanwhile, there were varied change of temperature and light intensity.

Table 2. Water quality of Central Borneo peat swamp in rainy and dry season

| Station | SHU | SHI | MKT | MTG | SAR | SJY | KER | SBL |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|
|         | WS  | DS  | WS  | DS  | WS  | DS  | WS  | DS  |
| Temperature °C | 31.1 | 31.1 | 29.9 | 29.9 | 29.0 | 28.4 | 29.2 | 29.6 |
| Depth (m) | 4.2 | 3.2 | 5.4 | 5.4 | 4.2 | 4.0 | 4.4 | 2.8 |
| Light intensity (cm) | 75.0 | 75.0 | 43.5 | 43.5 | 59.3 | 66.0 | 62.5 | 52.5 |
| Conductivity (µmhos) | 10.8 | 10.8 | 4.9 | 4.9 | 9.9 | 13.2 | 6.6 | 9.4 |
| DO (mg/L) | 2.5 | 2.5 | 2.4 | 2.4 | 3.2 | 3.2 | 3.2 | 3.2 |
| Velocity (cm/s) | 0.5 | 0.5 | 0.2 | 0.2 | 0.6 | 0.6 | 0.5 | 0.6 |
| pH        | 4.5 | 4.5 | 4.4 | 4.4 | 4.4 | 4.6 | 3.9 | 4.2 |

The number of species and density of phytoplankton and zooplankton were also varied in seasons and sampling sites (Figure 2 and 3). There were some locations with few numbers of species and less density, locations with various species and high density of plankton. Furthermore, there were contrast appearances of phytoplankton and zooplankton between sampling periods.

The number of species and the density were higher in rainy (wet) season than in dry season. Six classes of phytoplankton with 56 and 41 species were found in rainy (wet) and dry season. Those were seven and five genera of Cyanophyceae, three genera of Euglenophyceae, 28 and 17 genera of Chlorophyceae, one genus of Cryptophyceae, 16 and 14 genera of Bacillariophyceae, and one genus of Dinophyceae, in rainy (wet) and dry season, respectively.
Figure 2. Number of phytoplankton species at rainy (wet) and dry season

Figure 3. Density of phytoplankton species at rainy (wet) and dry season

Based on the density of each phytoplankton species, there were calculations for the diversity index (Shannon-Wiener/H’, Evenness/E, and Simpson/C). The values of all indices are presented in Figure 4. The figure showed that most of H’ values are relatively low. The E values are relatively fair, with some contrast to C values at several locations, especially at MKT and SBL.
Figure 4. Biological index of phytoplankton at rainy (wet) and dry season

There are four clusters of location in rainy (wet) season. The MKT, SAR, and KER, where each of them were constructed as separated clusters. Similar clusters were found in dry season (Figure 5 and 6).

Figure 5. Cluster of station of rainy (wet) season based on phytoplankton density

Figure 6. Cluster of station of dry season based on phytoplankton density
A total of 36 species of zooplankton was found, consisting of Protozoa (18 genera), Rotifers (16 genera), Crustacean (Five genera), and Nematods (one genus). Most of those species utilize organic materials as source of energy, and the others consume phytoplankton. The number and density of zooplankton species from rainy (wet) and dry season as presented in Figure 7 and 8 is relatively low. This is related to the extreme condition of water.

![Figure 7. Number of zooplankton species at rainy (wet) and dry season](image1)

![Figure 8. Density of zooplankton species at rainy (wet) and dry season](image2)

The diversity indices of zooplankton are presented in Figure 9. As the phytoplankton, the value of Shannon-Wiener Index was lower in dry season. There were relatively high values of E in both seasons. It means that the zooplankton has high possibility to develop in sync with the change of natural condition of the aquatic ecosystem.
Figure 9. Diversity index of zooplankton at rainy (wet) and dry season

The relationship between the two plankton communities and water quality are described in biplot of PCA (Figure 10 and 11). As it shown in the figures, relationship between plankton communities and water quality showed different pattern, including spatial distribution of plankton.

Figure 10. Biplot of plankton community and water quality in wet season

Figure 11. Biplot of plankton community and water quality in dry season
4. Discussion

Water quality does not significantly differ in response to different seasons; only some values of conductivity from some stations showed lower values in wet season. Based on data analysis, changes took place on the surface does not affect the quite stable water (catotelm area); and water does not move laterally in the catotelm [4].

However, the precipitation dilutes dissolved materials in the water. Conductivity represents dissolved materials or bioavailable nutrients. As a result, there could be some effects to the existence of phytoplankton community as nutrients user.

The low pH value characterize peat swamp water condition, and this coincided with the other result study that make long series measurement of water quality of Central Kalimantan peat swamp water from 2004-2007[4]. The low pH detains organic decomposition and instigate low aquatic productivity related to low concentration of nutrients.

The artificial drainage developed during preparation of Mega Rice Project in Central Kalimantan peat swamp has changed hydrological pattern of the peat swamp. This reveals different nutrients dynamic, both in peat soil and in the water. The sole source precipitation water will give less support to nutrient since the water flows throughout the system.

KER has the highest number of species compared to the other location and this is due to the less flow of water in this location. Many types of phytoplankton could live in community with adequate nutrients since the organic material is well decomposed. The stagnant condition is very important for phytoplankton in order to utilize nutrient and other condition to develop.

There were several species of filamentous types of phytoplankton found and showed high density in SJY and KER. The species number of Chlorophyceae in KER was relatively high, both in rainy (wet) and dry season. The stagnation condition of the water was suitable for the filamentous types as found in both locations.

Dinophyceae and Chrysophyceae species showed the lowest number and density. The species of these two groups were also found in several clean water ecosystems or less nutrient concentration at the upstream of East Kalimantan and West Jawa [20, 21].

A huge change in both number of species and density were found at SHU and MTG. Both locations are lotic waters such as natural river and artificial channel. The difference between two seasons in both stations was depth of waters. The water quality will be highly fluctuated in shallower waters. This lead the survivor sustained, and the rest failed to develop.

Those values indicated that phytoplankton community in aquatic ecosystem of Central Kalimantan peat swamp was not stable. This was shown in two periods of observation that the structure of phytoplankton community has changed. The less stability of phytoplankton community structure indicated that the species composition will change over time. The change was driven by the change of several parameters of water quality (Table 1). There were specific characteristic of peat swamp phytoplankton community found in this region. The species of Desmids and Chlorococcales were dominant, and most of phytoplankton was in small size.

The low number and density species of phytoplankton in dry season were driven by high level of temperature and lower pH condition. The capacity of metabolism that supposed to be raised at higher temperature was not supported by the low level of pH. It was presumed that the availability of nutrients was bent as the low pH condition was not suitable for decomposition and mineralization process. Furthermore, there is lack of biological available nutrients to support growth and development of phytoplankton although in adequate light condition.

Undisturbed natural peat soils might hold 80-90% of water. This huge capacity to keep great amount of water makes peat swamp ecosystem to play a significant roles in reducing flood and sustaining water security. However, there is a specific characteristic of peat swamp water, especially the colour.
Peat soil, itself, has specific characteristic, such as (1) hydrologically, having high capacity in storing water such as sponge, reaching 15-20 times of its dry weight; (2) hydro-pobicity, irreversible characteristic of dry condition which create low fire resistance; (3) higher capacity in flowing water horizontally than vertically, and this makes easy to dry off; (4) high capacity in storing carbon [1].

Tropical swamps are widely distributed. Some of them are found in Latin America, Africa, and Caribia. Most of them, for about 33 million hectare, are found in East Asia; and the 27 million hectare of it is located in Indonesia. The rest is located in small areas, such as in Malaysia, Philippines, Thailand, and Vietnam. Unfortunately, some of the peat area have been lost due to forest fire, logging, and land opening.

The number of zooplankton genera varies spatially. As found in Thailand peat swamp, the Rotifers showed the highest number of species [10]. This study showed that the highest density and number of species was found at SAR. This condition was not supported by the presence of phytoplankton. This raises presumption that the zooplankton prefers to utilize organic material from phytoplankton.

There was decreasing number and density of zooplankton from rainy (wet) season to the dry season. The drastic change in number of species was shown by the sample from SHU and MKT, while in density was found in SAR.

In rainy (wet) season, phytoplankton was highly correlated to depth, conductivity, and water current condition. Then, in dry season, phytoplankton was correlated to the water flow. The zooplankton was highly correlated to depth, conductivity, and water current in rainy (wet) season; and highly correlated to water current in dry season.

It was shown that the appearance of both plankton communities were highly influenced by physical condition, especially water current. Water current was also correlated to other parameters, such as particles and ionic materials. The ionic materials is expressed as conductivity. Those parameters illustrated the available nutrients condition.

5. Conclusion
The numbers of species were higher in wet season than in dry season. The most different conditions between the seasons were water current velocity and depth of waters. The plankton communities were highly correlated to depth, conductivity, and water current condition.

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