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Research Article

Assessment of Spatial Variability and Temporal Dynamics of Dissolved Organic Matter (DOM) at Lower Kinabatangan River Catchment, Sabah.

Norizati Murdin[1*], Harry Chong Lye Hin[2], Salani Selveno[1], Sahana Harun[1], Arman Hadi Fikri[1]

[1]*Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, 88400 Jalan UMS, Kota Kinabalu, Sabah, Malaysia.*
[2]*Faculty of Science and Natural Resources, Universiti Malaysia Sabah, 88400 Jalan UMS, Kota Kinabalu, Sabah, Malaysia.*

*Corresponding author: norizatimurdin@gmail.com

Abstract

The spatial and temporal variability of dissolved organic matter (DOM) characteristics and surface water quality in the Lower Kinabatangan River Catchment were determined between October 2015 and May 2016. The objectives of this study were: (i) to distinguish the DOM absorption characteristics and physicochemical quality of surface water draining from different types of land use: oil palm plantation (OP), secondary forest (SF) and semi-natural vegetation (SV); and to examine its temporal variations during dry and wet periods. The collected physicochemical parameters data was analysed and classified based on the Malaysian National Water Quality Standard (NWQS). Findings indicated all the parameters fall into Class I, except for pH, total suspended solids (TSS) and concentration dissolved oxygen (DO). Linear discriminant analysis has been applied to distinguished the physico-chemical and absorption DOM properties data into mutually-exclusive spatial and temporal groups. Interestingly, the pH, DO and total nitrogen values were exhibited as dominant parameters at SV during both low and high rainfall periods. The dominance of these parameters suggested that the spatially and temporally varied water quality were influenced by both natural processes (e.g precipitation rate) and anthropogenic factor (e.g land use change). Whereas, both absorption coefficients (a_{340}) and spectral slope ($S_{275\text{-}295}$) were more dominant at SF and OP respectively. This might be due to increasing terrestrial DOM loadings as well as significant degradation of DOM via microbial and/or photochemical reaction.

Keywords: Dissolved organic matter (DOM), physico-chemical water quality, Lower Kinabatangan River Catchment.

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Introduction

Tropical river catchment is a complex ecosystem, linking various components with each other; biotic and abiotic, terrestrial and aquatic, plants and soils, atmosphere and vegetation, and soils and water (Giller & Malmqvist, 1998; Baxter et al., 2005). However, despite its well known ecological importance, significant areas of the tropical catchment are increasingly disappearing over the years as a result of development and economic gains. Changes in the catchment surface characteristics have been found to disrupt the components of hydrologic system in the region such as streamflow, surface runoff, groundwater recharge as well as water quality (Shukla et al., 2014). Conversion of forested areas to agricultural land also result in increased rate of sediment loads, surface runoff and nutrient influx (Jakobsen et al., 2007). As the tropical river system is characterized by a distinct annual cycle in precipitation, rain period and high solar radiation (Saigusa et al., 2008), temporal variant may also create a difference in the flow velocity, water chemistry and metabolic rates (Tan et al., 2017).

The spatial and temporal variability of water chemistry has been previously addressed in other studies. The findings by Tan et al. (2017) indicated water temperature, total suspended solids (TSS) and conductivity were varied spatially at different types of land use at Maliau Basin Conservation Area (MBCA), while the values of pH and concentrations of dissolved oxygen (DO) displayed variation during dry and wet period respectively. Harun et al. (2014) had reported seasonally variable contributions of TSS and chemical oxygen demand (COD) at the Lower Kinabatangan River Catchment, with higher values during the wet season. However, precipitation anomalies had been identified in the duration of the study period during 2005/2006, which explained by the occurrence of a weak La Nińa event. In another water quality study within the same catchment area, significant variations of dissolved organic matter (DOM) were also observed by Harun et al. (2016), with respect to types of land use and seasonal variability. The characterization of DOM quality and quantity on both spatial and temporal scales is important as it reflects the proper functioning of the aquatic ecosystem.

Riverine DOM is a heterogeneous mixture of various organic compounds in natural water. The aggregations of these molecules had increased the complexity of DOM structure which described its reactivity and bioavailability within the aquatic ecosystem (Aiken et al., 2011; Bejarano et al., 2015; Yates et al., 2016). Allochthonous DOM made up major aquatic DOM pool, along with *in-situ* heterothropic and anthropogenically derived DOM. As rivers at the lower catchment areas are usually wider, slower-flowing water and less coverage by forest canopy as compared to the upper catchment (Harun, 2013), the autochthonous DOM may play a more important role in this part of the river where higher penetration by sunlight may increase microbial activities and photochemical reaction in water bodies. Characterization of the quality and quantity of DOM by spectroscopic measurement has been widely applied, as it enables quick analysis and low operational cost. Numerous studies on the amount and composition of DOM had demonstrated its significant role in examining land use conversion and anthropogenic activities that influence the local surface water quality, for instance, findings by Limpens et al. (2008) showed that the DOM in oil palm plantations seems to have a significant signature.

This paper focuses on the characterization of the absorption bands of riverine DOM in the UV-Visible range and surface water quality in forested and agricultural catchments during both dry and wet periods. The quality of DOM and surface water draining from three different types of land use (oil palm plantation, semi-natural vegetation and secondary forest) at Lower Kinabatangan River catchment were explored in this study. The rapid expansion of agricultural land was known to have a profound effect on the aquatic ecosystems as well as altering the quantity and quality of DOM. Although the water quality study had been previously conducted within the same river catchment areas, both spectroscopic DOM properties in the UV-visible range and physico-chemical water quality have not been addressed in any publication. In addition, the study also aims to provide a better understanding on water quality trend analysis and its relationship to the water quality of the lower Kinabatangan river, which highlights the crucial requirement of consistency in water quality monitoring.

Methodology

Study site

The Lower Kinabatangan River Catchment is located on the east coast of the Malaysian state of Sabah. The river flows 560 km easternly from its headwaters in the Southwest region of Crocker Range to the Sulu Sea (Boonratana, 2013; Fletcher, 2009). It is the second longest river in Malaysia, draining a total of 16,800 square km of water catchment area or about 23% of the total land area of Sabah. Lower Kinabatangan land areas can be classified into natural rainforest wetland habitat, agriculture and village settlement (Fletcher, 2009). Currently, almost half of the Kinabatangan district is dominated by agricultural areas, mainly oil palm and a very small percentage of other crops. Oil palm is grown on cleared vast area of forest land or logged areas that were transformed into plantations. Malaysia had become the second biggest palm oil exporter in the world, with Sabah as the major contributor in total production of palm oil in the country.

Sample collection and in-situ *analysis*

A total of 12 sampling stations were selected along the lower reaches of Kinabatangan River (Table 1). Sampling was conducted based on its accessibility and characterized by three types of land use which included oil palm plantation (OP), semi-natural vegetation (SV) and secondary forests (SF) (Figure 1). A total of 60 surface water samples were collected during the fieldwork campaigns (October to November 2015 and March to May 2016). The collected samples were stored in 200 mL of high-density polyethylene (HDPE) bottles, which are pre-washed with 10% hydrochloric acid to avoid contamination. Samples filtration were immediately conducted using Whatman GF/F glass fibre filter. Samples collected were acidified using HCl to pH~2 for preservation until further DOC analysis at Universiti Malaysia Sabah (UMS). In-situ water quality parameters were determined by using a YSI Profesional Plus (ProPlus) (Model 6026 S/N Y5173) multiparameter.

Table 1. Sampling stations and its GPS coordinates

Selected rivers	Stations	GPS coordinates
Pin River (SV1)	P1	N 05° 23.901 E 117° 56.087
	P2	N 05° 23.788 E 117° 56.096
	P3	N 05° 23.682 E 117° 56.093
Takala River (SV2)	T1	N 05° 25.056 E 117° 58.814
	T2	N 05° 24.114 E 117° 58.781
	T3	N 05° 24.056 E 117° 58.743
Resang River (OP)	R1	N 05° 32.973 E 118° 20.159
	R2	N 05° 32.933 E 118° 20.209
	R3	N 05° 32.903 E 118° 20.255
Menanggol River (SF)	M1	N 05° 30.293 E 118° 16.389
	M2	N 05° 30.284 E 118° 16.328
	M3	N 05° 30.276 E 118° 16.260

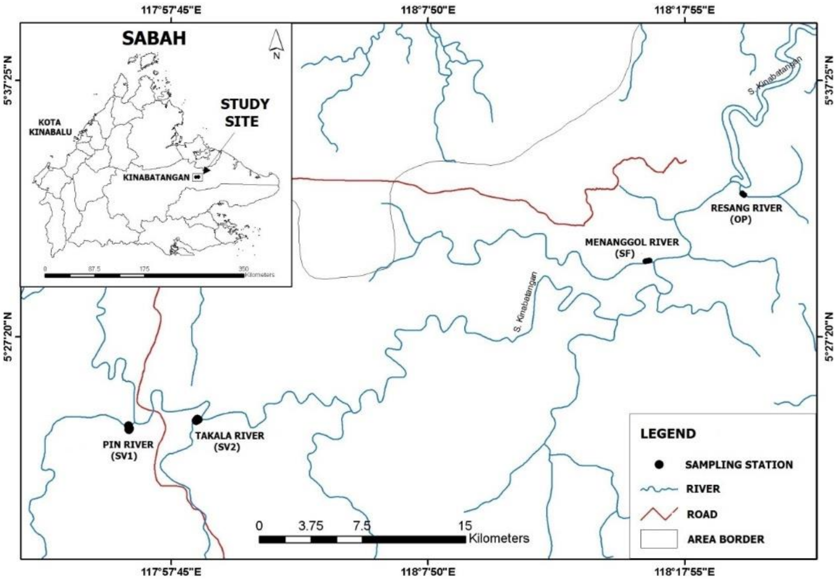

Figure 1. The locations of sampled rivers

Spectroscopic DOM analysis

In this study, Agilent Cary 60 UV-Visible Spectrophotometer were used to measure the UV-visible absorption spectra of DOM within all samples with deionized water used as a reference. The absorption spectra were obtained between a wavelength of 200 nm to 800 nm and each data were collected at 1 nm intervals. The wavelength of 200-400 nm was selected to represent the ultraviolet (UV) of a region of the light spectrum, while 400-800 nm represented the visible light portion. All the samples were allowed to reach room temperature before spectrophotometric analysis began. The reason was to avoid the condensation to form on the wall of the cuvette (Carter et al., 2012) and interfere with the spectrum of radiation from the spectrophotometer. The surface cuvette was also cleaned before measurement to keep the reflection and scatter losses to a minimum. Then, absorption spectra recorded by the spectrophotometer were converted to absorption coefficient using Beer-Lambert Law (1). Beer's Law states that the absorption of light is directly proportional to both the concentration of the absorbing medium and the thickness of the medium of the light path (Dhikale et al., 2015).

$$\alpha = 2.303*A/l \quad (1)$$

Where α is absorption coefficient, A is the absorbance of the sample by the spectrophotometer and l is the path length of the cuvette in meters. The absorption coefficient was obtained at wavelength 340 nm (a_{340}). This wavelength was used to characterize dissolved organic matter as organic molecules absorb and reacts with UV light in this wavelength (Baker et al., 2004). Besides that, the spectral slope from the wavelength interval of 275 to 295 nm ($S_{275-295}$) was also identified and calculated as a linear regression of the log transformed spectra. Absorption coefficient a_{254} and a_{340} were used to indicate the concentration of chromophoric DOM while spectral slope has been widely used to indicate the molecular weight and aromaticity of DOM (Helms et al., 2008).

Dissolved Organic Carbon analysis

Shimadzu TOC-L Analyzer with auto-sampler ASI-L was used to determine the concentrations of dissolved organic carbon (DOC) in the sample. Catalytic combustion oxidation method was used in this analysis, which involves complete oxidation of carbonaceous materials with the aid of a catalyst. Prior to sample analysis, all the samples were allowed to warm to room temperature (Loginova et al., 2016), which then acidified and sparged for 8 minutes at 75 or 100 mL/min with ultra-pure oxygen. These steps were carried out to remove the inorganic carbon compounds from the samples (Zigah et al., 2012). Apart from that, the concentration of dissolved nitrogen (DN) were also determined using this method.

Statistical analysis

Linear discriminant analysis (LDA) were applied to classifying physicochemical water quality and spectroscopic DOM properties into mutually exclusive spatial and temporal groups. Discrimination between groups and minimisation of misclassification error rates resulted in a linear combination of these parameters (Gazzaz et al., 2012). The LDA standardized coefficient out represents the partial contribution of the physicochemical and spectroscopic DOM properties and rank the importance of each parameter to the discriminant function (Tan et al., 2017). Statistical analysis of linear discriminant analysis (LDA) was run by using R statistical software 3.4.4.

Result and discussion

Rainfall data and environmental condition during sampling session

The Lower Kinabatangan River Catchment had received 2614.0 mm of the total annual rainfall for 2015, followed by approximately 2494.8 mm recorded in 2016 (Figure 2). The wet period (the total monthly rainfall is slightly above than the average annual rainfall each respective year) for the sampling occasions were recorded in November 2015 and May 2016. Meanwhile, the dry period was taken in October 2015, March and April 2016 (the total monthly rainfall is slightly lower than the average annual rainfall each respective year). The lowest rainfall was recorded during March 2016 (third sampling session) with significantly reduced river water levels, followed by April 2016 and October 2015. Rainfall data in December 2016 is unavailable.

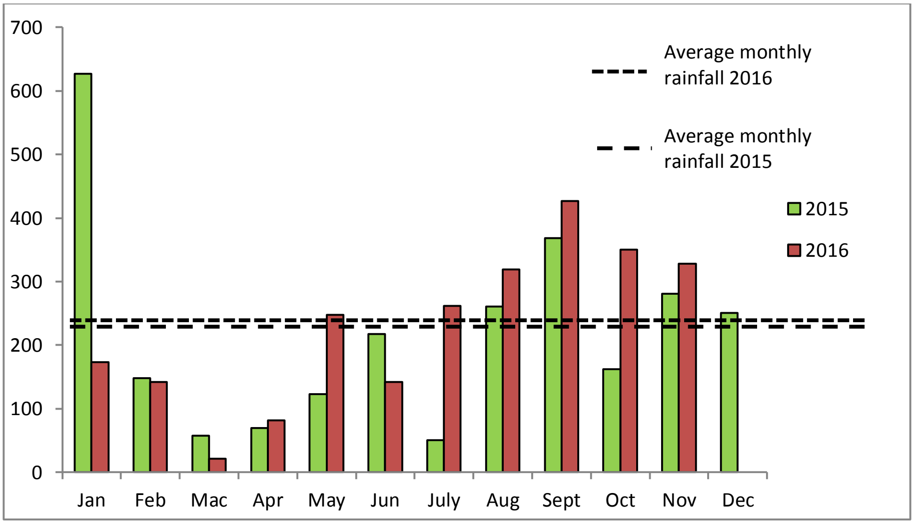

Figure 2. Monthly rainfall data recorded at Lower Kinabatangan River Catchment from January 2015 until November 2016. (Meteorological Department, Kota Kinabalu)

Surface water quality

Most of the water quality parameters in this study were classified under Class I, based on the Malaysian National Water Quality Standards (NWQS), except for dissolved oxygen (DO), total suspended solids (TSS) and pH values categorized as class IV. The water quality at Lower Kinabatangan River catchment was considered to be polluted and suitable to be used only for irrigation purposes. The low pH level and high TSS concentration were observed at agricultural-based land use (OP and SV) compared to SF (Table 2). Although loads of organic matter usually higher during land preparation and planting periods within young oil palm plantation, lack of land cover by vegetation as well as the unpaved road of harvesting path of mature plantations at OP may have caused significant soil erosion and washed into the river. As organic matter are naturally acidic, increase in its concentration

Table 2. Mean ± SE of physicochemical and spectroscopic parameters at Lower Kinabatangan River Catchment during different sampling months.

	pH	Temperature °C	Conductivity µS/cm	DO mg/L	TSS mg/L	DN mg/L	DOC mg/L	a_{254} /m	a_{340} /m	$S_{275-295}$ /nm
Semi-natural vegetation (SV)										
Oct 2015	6.8 ± 0.4	28.1 ± 0.7	242.1 ± 3.5	5.1 ± 0.1	399.9 ± 21.9	1.4 ± 0.4	9.0 ± 0.4	144.0 ± 32.4	74.1 ± 26.8	0.008 ± 2.2×10^{-3}
Nov 2015	7.1 ± 0.3	26.5 ± 0.3	174.0 ± 38.9	4.5 ± 0.4	320.8 ± 96.8	0.9 ± 0.4	6.1 ± 0.7	100.3 ± 4.2	47.1 ± 1.8	0.009 ± 2.0×10^{-4}
Mar 2016	8.2 ± 0.7	32.8 ± 0.8	226.8 ± 43.7	5.8 ± 1.5	25.8 ± 9.7	N/A	7.2 ± 1.8	75.6 ± 29.3	34.3 ± 5.8	0.010 ± 1.1×10^{-3}
Apr 2016	6.6 ± 0.2	30.2 ± 1.2	265.8 ± 57.1	2.4 ± 0.4	199.6 ± 41.6	3.4 ± 0.4	9.1 ± 1.8	85.1 ± 5.4	63.6 ± 5.6	0.009 ± 3.4×10^{-4}
May 2016	7.5 ± 0.6	34.2 ± 1.6	152.4 ± 28.4	7.8 ± 2.9	54.8 ± 14.5	0.5 ± 0.2	7.8 ± 2.5	92.6 ± 7.4	70.3 ± 14.2	0.008 ± 3.9×10^{-4}
Oil Palm Plantation (OP)										
Oct 2015	6.5 ± 0.2	28.4 ± 0.7	411.8 ± 71.7	3.1 ± 0.4	56.3 ± 19.3	0.8 ± 0.2	8.8 ± 1.4	114.3 ± 18.3	49.6 ± 5.4	0.010 ± 3.5×10^{-4}
Nov 2015	4.0 ± 0.0	27.2 ± 0.1	875 ± 69.3	2.6 ± 0.1	53.9 ± 2.0	0.9 ± 0.0	9.6 ± 0.1	116.0 ± `.3	45.9 ± 1.2	0.013 ± 3.5×10^{-4}
Mar 2016	7.3 ± 0.0	30.5 ± 0.2	372.3 ± 46.1	4.1 ± 0.1	39.6 ± 6.8	N/A	9.3 ± 0.6	`07.2 ± 45.5	60.4 ± 9.5	0.010 ± 3.8×10^{-4}
Apr 2016	6.4 ± 0.2	31.3 ± 0.1	166.6 ± 47.7	3.5 ± 0.4	349.3 ± 56.6	0.4 ± 0.1	8.6 ± 2.7	91.9 ± 10.0	54.2 ± 2.7	0.009 ± 2.5×10^{-4}
May 2016	4.2 ± 0.1	27.8 ± 0.3	516.3 ± 19.0	4.5 ± 0.3	75.8 ± 8.1	1.8 ± 0.4	6.8 ± 0.2	91.13 ± 8.7	44.9 ± 0.5	0.008 ± 2.1×10^{-4}
Secondary forest (SF)										
Oct 2015	6.5 ± 0.1	28.4 ± 0.2	176.3 ± 44.7	3.0 ± 0.9	55.2 ± 5.9	0.8 ± 0.2	7.5 ±1.9	113.8 ± 8.4	51.9 ± 1.3	0.010 ± 8.9×10^{-4}
Nov 2015	6.4 ± 0.1	26.6 ± 0.0	188.6 ± 0.9	1.5 ± 0.0	14.7 ± 4.5	0.4 ± 0.0	16.0 ± 0.4	300.9 ± 2.4	122.0 ± 1.5	0.012 ± 1.5×10^{-4}
Mar 2016	7.5 ± 0.1	30.5 ± 0.1	128.3 ± 1.3	4.1 ± 0.2	24.6 ± 0.6	N/A	12.0 ± 2.2	89.8 ± 31.5	59.1 ± 5.1	0.009 ± 2.1×10^{-4}
Apr 2016	6.9 ± 0.1	31.0 ± 0.3	90.1 ± 3.5	3.6 ± 0.6	90.9 ± 10.7	0.2 ± 0.2	6.2 ± 3.6	89.4 ± 5.8	74.9 ± 8.7	0.009 ± 3.5×10^{-4}
May 2016	6.2 ± 0.0	29.4 ± 0.1	74.1 ± 0.1	4.0 ± 0.2	142.7 ± 6.1	0.4 ± 0.0	5.3 ± 0.9	88.7 ± 2.6	66.8 ± 2.2	0.008 ± 5.7×10^{-5}

N/A – Data not available

may lower the pH level at OP. Apart from that, fertilizer usage such as ammonium-based nitrogen fertilizer may cause plantation soil to be more acidic and may lower the pH when washed into the river. In addition, accumulation of organic matter at SF (DOC: 16 mg/L; Table 2) could lead to low concentration of DO (1.5 mg/L; Table 2). High organic matter content may limit the fluxes of photosynthetically available radiation (PAR) into the water column, thus decrease the aquatic primary production and release lesser dissolved oxygen compounds (Kelble et al., 2005; Mostofa et al., 2012).

The relationship between Absorption Properties of DOM and DOC concentrations
Quantification of dissolved organic matter (DOM) to assess the total concentration of organic compounds in the aquatic environments, are often represented as dissolved organic carbon (DOC) (Tan, 2014; Spencer et al., 2012; Zhang et al., 2013; Hansen et al., 2016). Many studies investigating the utility of spectroscopic DOM measurements to determine the concentrations of DOC in the freshwater ecosystem have revealed the strong correlation between absorbance values and riverine DOC. Highly correlated UV-visible absorption coefficients at 254 nm (a_{254}) and 340 nm (a_{340}) with DOC concentrations ($R^2 = 0.933$ and $R^2 = 0.915$, $p < 0.05$, respectively) have been observed in a DOM study of surface water in Maliau Basin, Sabah (headwaters system for Kinabatangan River Catchment) (Tan et al., 2017).

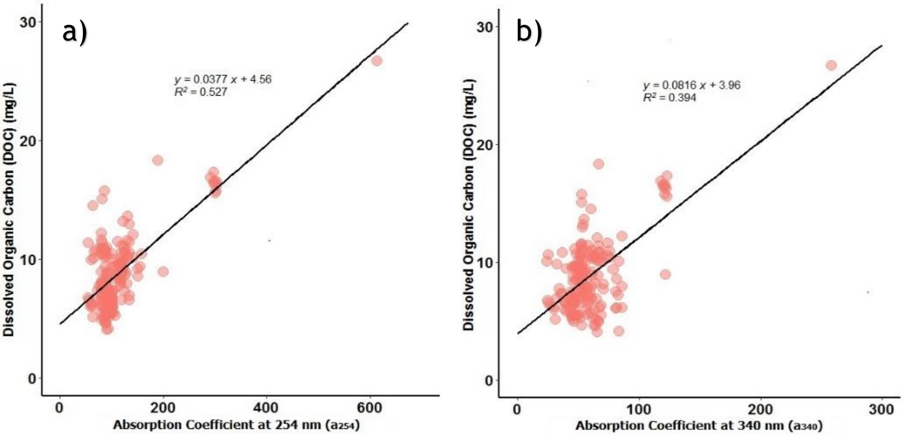

Figure 3. (a) – (b) UV-Visible absorption coefficients at 254 and 340 nm against DOC concentrations.

However, in this study, only weak to moderate relationships were obtained between DOM absorbance of a_{254} ($R^2 = 0.527$, $p< 0.05$, Figure 5.1) and a_{340} ($R^2 = 0.394$, $p<0.05$, Figure 5.2) and DOC concentrations. This suggested that the organic compounds fraction within the water column changes over time, that can either be dominated by organic compounds with poor UV-absorbing ability or/and light-absorbing chromophoric DOM fractions (Asmala *et al.*, 2014). As the Lower Kinabatangan River Catchment is comprised of various types of land use, exported DOM into the river may originate from a widerange of sources including forested areas as well as anthropogenically altered DOM from agricultural land and human settlements. These results thus suggest that the absorption coefficient at 254 and 340 nm were less suitable to be used as a proxy for DOC concentration in natural waters impacted by anthropogenic activities.

Spatial and temporal variation of water quality

Changes in water chemistry were greatly influenced by catchment characteristics as well as climatic conditions (Detail rainfall data of Lower Kinabatangan River Catchment is illustrated in Figure 2). In this study, the linear discriminant analysis (LDA) was applied to the dataset of physicochemical and spectroscopic DOM properties to investigate the spatial and temporal water quality patterns. As illustrated by the ordination plot of LDA (Figure 4 and Figure 5), water draining from different types of land use (SV, SF and OP) and sampling months showed significant variations with each other. Based on the LDA output (Figure 4 and Figure 5, Table 3), it has been found that pH, dissolved oxygen (DO), conductivity and total nitrogen (TN) were recognized as the dominant parameters in discriminating both spatial and temporal water quality pattern. Absorption coefficient at 340 nm (a_{340}) was able to only spatially discriminate water quality dataset, while the concentration of DOC and water temperature varied temporally.

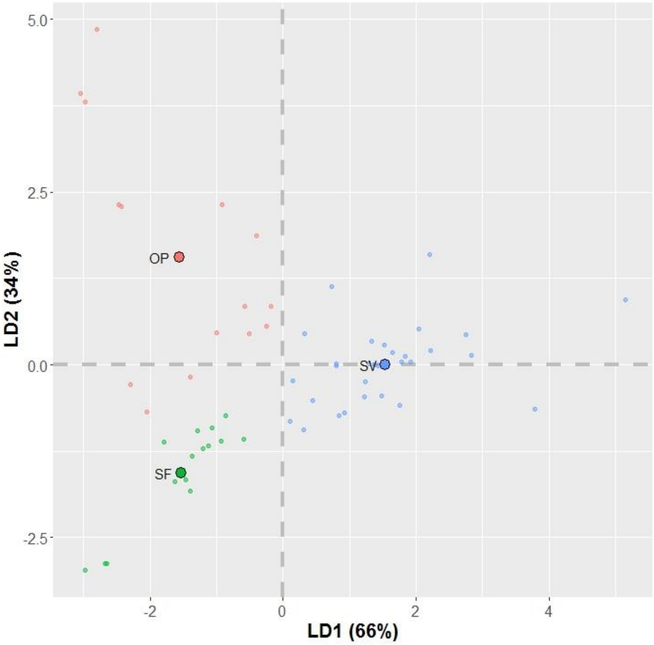

Figure 4. Linear discriminant analysis functions for each type of land use at Lower Kinabatangan River catchment (SV – Semi-natural vegetation, OP - Oil Palm Plantation, and SF - Secondary forest).

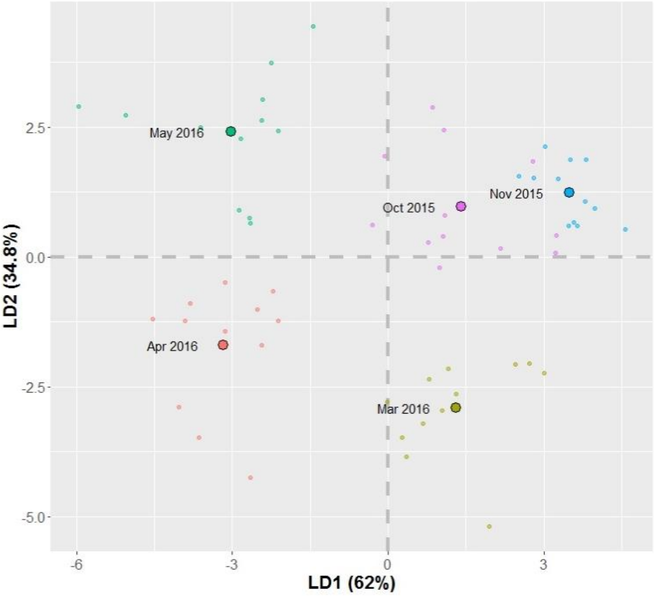

Figure 5. Linear discriminant analysis functions during different sampling months (October 2015, November 2015, March 2016, April 2016 and May 2016).

Table 2. Standardized linear discriminants coefficients and eigenvalue from the linear discriminant analysis that employed to examine the spatial and temporal variations of water quality at Lower Kinabatangan River catchment.

	Spatial Variation		Temporal Variation	
	LD1	LD2	LD1	LD2
pH	**1.32**	0.05	**1.88**	**-0.51**
Water temperature	-0.25	0.31	**-1.53**	**-0.50**
Conductivity	0.39	**1.11**	**1.33**	-0.10
Dissolved oxygen, DO	**0.84**	0.03	**0.60**	-0.02
Total suspended solids, TSS	0.40	0.20	-0.08	0.13
Dissolved nitrogen, DN	**1.14**	-0.08	**-0.50**	**0.75**
Dissolved organic carbon, DOC	-0.03	0.08	0.44	-0.37
a_{340}	0.15	**-0.52**	-0.09	0.34
$S_{275-295}$	0.02	**0.57**	0.48	-0.10
Eigenvalue	8.45	6.06	10.27	7.69

The pH level was observed to vary substantially across selected land use and tend to fluctuate inversely with precipitation events. Higher value of pH at SV was particularly determined during March 2016, while low pH reading was obtained in November 2016 (Table 2). Under a normal monsoon cycle, heaviest rainfall usually occurs between November to March (Northeast monsoon). However, the unexpected dry period of low rainfall was recorded during March 2016, with the apparent decline in water level of river observed within the vicinity of SV land use observed. High pH level obtained in this month was likely due to the low concentration of organic acid compounds in the river system (Pagano et al., 2014). Contrarily, heavy rainfall during November 2015 may increase DOM loadings into the fluvial system via leaching and surface run-off. As humic-rich DOM containing colloidal suspensions are generally acidic in nature, this leads to low pH during the wet period. (Fatema et al., 2014).

Results reveal that the mean DO concentrations recorded in this study ranges from 1.5 to 7.8 mg/L (Table 2). Since aquatic organisms are sensitive to DO levels, low concentrations of DO were highly harmful as at least 4 to 5 mg/L were required to sustain the normal functioning of a healthy ecosystem (Wang et al., 1978). Similar to pH level, high values of DO were also determined at SV. This may possibly occur due to the low quantity of organic acid present in the water column. In contrast, extremely low DO level was recorded during November 2015 (1.5 mg/L, Table 2), which may be due to the high concentration of DOC. Accumulation of organic matter was known to promotes the oxygen dependence reaction and limit the photosynthetically available radiation, thus lowered the DO level (Cory et al., 2015). Higher water temperature has been recorded during April 2016 (dry period), which reflect the significant exposure to solar radiation. The increase rate of light penetration may initiate the photosynthetic reaction in the water column, that resulted in a higher concentration of DO.

In regards to the comparison between different types of land use, concentrations of dissolved nitrogen (DN) were demonstrated to influence the spatial as well as temporal trends of water quality (Table 3). High concentrations of DN were recorded particularly at SV. Nutrient enrichment at SV had caused eutrophication where the extensive growth of algae was observed during the wet period (May 2016). The input of nitrogen compounds most probably originated from an oil palm plantation adjacent to the river channel. This finding was supported by Gharibreza et al. (2013) suggesting increased levels of nitrogen than natural forested content in Lake Bera catchment area that may result from the utilization of fertilizer by rubber and oil palm plantations. Over the years, nitrogen based fertilizer has been commonly used in the plantation to maximize productivity (Zin and Tramizi, 2007; Othman et al., 2014). The build up of nitrogen in agricultural soil was more easily leached away by rainwater into the aquatic system than most other essential elements (Vitousek et al., 2002; Khan et al., 2007).

Generally, conductive ions in the fluvial system are typically in accordance with the concentrations of dissolved solids and salts. Highest conductivity was exhibited by OP. Anthropogenic discharges and lack of riparian barrier in OP areas may applicable in explaining the spatial variability in conductivity values. In addition, high conductivity values obtained at OP may also be associated with the alluvial soils, which described by Acres and Folland (1975) to predominantly exist as silty clay loams in Kinabatangan areas. Clay soil were known to be readily ionized as it dissolved in water, raising the river conductivity levels. A spike in conductivity value occur during November 2015, as heavy rainfall during this wet period may enhance the rate of runoff from the terrestrial landscape.

Absorption coefficient at 340 nm (a_{340}) has been commonly used to quantitatively indicate the presence of chromophoric DOM (Baker and Spencer, 2004; Stedmon and Nelson, 2015). Chromophoric DOM was mainly represented by terrestrially derived DOM such as plant litter and soil organic matter. Thus, the predominance of a_{340} may suggest the accumulation of chromophoric DOM originated from the forested areas of SF. On the other hand, high calculated values of spectral slopes ($S_{275-295}$) were exhibited at OP. These spectroscopic properties of DOM generally used to qualitatively describes the shifts in the composition of DOM (Helms et al., 2008), higher values of $S_{275-295}$ indicates DOM with lower molecular weight and aromaticity as observed at OP land use. Low molecular weight and aromaticity of DOM might have resulted as a by-product of microbial processing and/or photochemical degradation.

Conclusion

Based on the evaluation of surface water quality properties, it is concluded that the sampling stations at Lower Kinabatangan River catchment were generally considered to be polluted as pH, DO and TSS parameters were classified under class IV, according to Malaysian National Water Quality Standard (NWQS). The surface physicochemical water quality properties were also spatially and temporally varied as illustrated by graphical LDA output, where findings showed that pH, DO and TN was significant at SV, while conductivity at OP. This suggests these parameters were influenced by agricultural activities as well as precipitation rate, where higher values were observed during both dry and wet periods. On the other hand, the spectroscopic data of DOM were only varied at different types of land use. High values of a_{340} at SF indicates accumulation of terrestrial DOM, while dominant $S_{275-295}$ at OP reflect the alteration of DOM either by the microbial or photochemical reaction. Further studies are is needed to characterise DOM composition in more detail as well as to compare DOM dynamics in headwaters and the lower part of the river to better understanding its functions within the tropical catchment.

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