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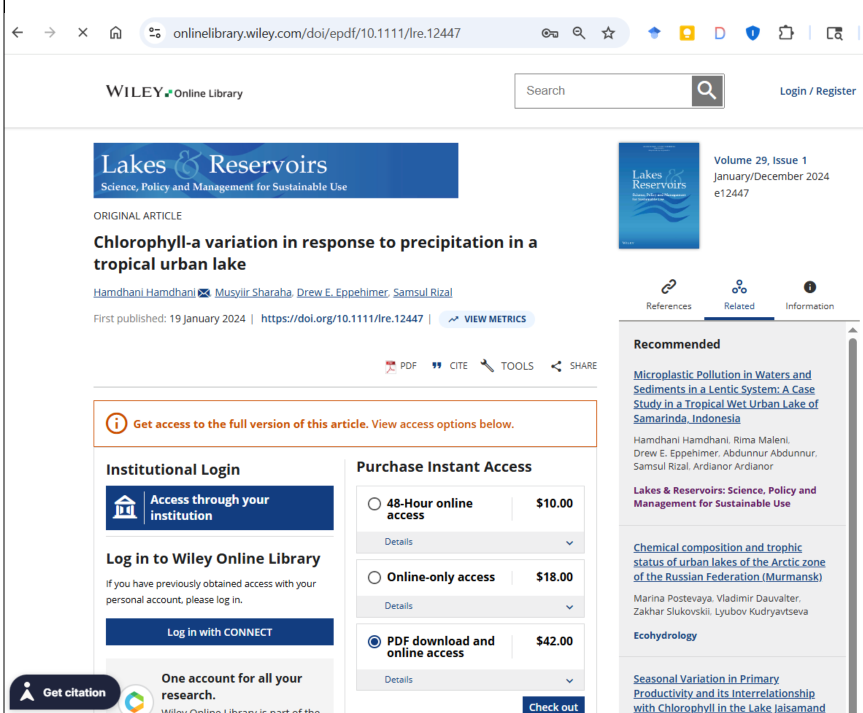
Link paper		1) Link Resmi **WILEY** (berlangganan) https://onlinelibrary.wiley.com/doi/epdf/10.1111/lre.12447  2) Repository Pribadi (link alternatif: open access) https://www.dropbox.com/scl/fi/pp5ybfc81g7u7q6z0v5ut/Hamdhani-et-al-24-Chlorophyll-a-variation-in-response-to-precipitation-in-a-tropical.pdf?rlkey=vsqoy323bjblizxuotvei8wvp&st=9m4amfc6&dl=0

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No.	Perihal	Tanggal	Link Bukti
1	Bukti konfirmasi submit artikel dan artikel yang disubmit	13 Mei 2023	**a) Email konfirmasi** **b) Laman akun jurnal** **c) Cover Letter** **d) Manuskrip yang disubmit**

a. Email konfirmasi

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1 message

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Your manuscript entitled "Chlorophyll-a variation in response to precipitation in a tropical urban lake" has been successfully submitted online and is being delivered to the Editorial Office of *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use* for consideration.

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Manuscript Files

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Abstract

With increasing urbanization, urban lakes are becoming more common and serve as important flood control infrastructure, recreational uses, as well as habitat for a variety of biota. However, given their construction, function, and location, urban lakes are susceptible to disturbances including stormwater runoff from metropolitan catchment areas. For example, nutrient loading from stormwater runoff can cause eutrophication. Chlorophyll-a concentration is an important water quality parameter because it can be used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. In this study, we examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. Chlorophyll-a, precipitation, and several basic water quality parameters were sampled at five stations during the 2022 rainy season. The data indicate that chlorophyll-a concentrations are negatively correlated with recent precipitation ($r^2=0.71$, $p<0.05$). This relationship is likely a result of dilution from increased lake volume. Although urban runoff is expected to increase nutrient loading, our monitoring indicates that dilution can mediate this process. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations. Further studies are necessary to better understand these urban aquatic ecosystems to continue to improve future management efforts.

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Additional Information

Is your data available?

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Keywords

chlorophyll-a; precipitation; lake; Samarinda; Indonesia

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c. **Cover Letter**

May 12, 2023

Dear *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use* editors:

Please consider the attached manuscript, "***Chlorophyll-a variation in response to precipitation in a tropical urban lake***", for publication as an original article in an upcoming issue of *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use*. The research described within was conducted as part of my research work at the Mulawarman University-Indonesia in collaboration with a scientist from the University of Arizona-USA.

Chlorophyll-a concentration is an important water quality parameter because it can be used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. We examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations.

We hope this study will expand our understanding on the relationship between chlorophyll-a and precipitation in urban tropical lake worldwide.

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d. **Manuskrip yang disubmit**

Chlorophyll-a variation in response to precipitation in a tropical urban lake

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Abstract

With increasing urbanization, urban lakes are becoming more common and serve as important flood control infrastructure, recreational uses, as well as habitat for a variety of biota. However, given their construction, function, and location, urban lakes are susceptible to disturbances including stormwater runoff from metropolitan catchment areas. For example, nutrient loading from stormwater runoff can cause eutrophication. Chlorophyll-a concentration is an important water quality parameter because it can be used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. In this study, we examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. Chlorophyll-a, precipitation, and several basic water quality parameters were sampled at five stations during the 2022 rainy season. The data indicate that chlorophyll-a concentrations are negatively correlated with recent precipitation ($r^2=0.71, p<0.05$). This relationship is likely a result of dilution from increased lake volume. Although urban runoff is expected to increase nutrient loading, our monitoring indicates that dilution can mediate this process. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations. Further studies are necessary to better understand these urban aquatic ecosystems to continue to improve future management efforts.

Keywords: chlorophyll-a, precipitation, lake, lentic, Samarinda, Kalimantan, Indonesia

Introduction

The world is becoming increasingly urbanized resulting in a myriad of effects on ecosystems (Elmqvist et al., 2013). Concomitant with increases in urbanization are increases in the abundance of urban water bodies (Strokal et al., 2021). Urban water bodies, both lentic and lotic, are characterized by higher influence from anthropogenic activities and as a result have altered ecosystems that may require different monitoring standards than natural systems (Schueler dan Simpson, 2001; Naselli-Flores, 2008). Consistent patterns of alterations that occur in urbanized streams/rivers have been identified by Walsh et al. (2005) and defined as the "urban stream syndrome", whose characteristics include a flashier hydrograph, altered channel morphology and stability, and elevated concentrations of nutrients and contaminations. These urban stream syndrome characteristics have frequently been documented in temperate regions but are also likely to occur in tropical regions and in different types of water bodies, including lakes (Yule et al., 2015; Lee et al., 2019).

Urban lakes differ from natural lakes in a number of ways. For example, they are usually smaller and shallower, and the majority are man-made, also known as constructed lakes (Schueler dan Simpson, 2001). As constructed lakes, their water bodies tend to have geometric shapes and often function as flood control infrastructure, water storage, and/or for recreational uses (Naselli-Flores, 2008). These constructed lakes often have area/drainage area of at least 10:1, meaning that the catchment area strongly influences the lake (Schueler dan Simpson, 2001). The rainfall-discharge variation in the catchment area drives water quality dynamics in corresponding water bodies (Jakeman and Hornberger, 1993), and this relationship is more pronounced in urban lentic systems. Because urban stormwater runoff typically originates from impervious surfaces and often comes into contact with human organic waste, it can collect larger amount of nutrients than runoff in less developed areas (Miller et al., 2014). Because they function as retention rather than flow conveyance, urban lakes are typically more sensitive to nitrogen and phosphorus loading from stormwater runoff than rivers or streams (Kakade et al., 2021). Therefore, water quality changes resulting from this nutrient loading can be a concern for managers, especially when the urban lake is used for recreation or water storage for consumptive use. Increases in urban development can result in nutrient loading that promotes rapid algal growth, destabilizes ecological balance, and impairs lake water quality (Qin et al., 2013; Alprol et al., 2021), which could not only exceed thresholds for aquatic biota but might also exceed health standards for humans.

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll-a as an essential photosynthetic pigment and require sunlight and carbon dioxide in order to live and grow. The excessive growth of phytoplankton due to nutrient enrichment can lead to eutrophication, which is the condition of imbalanced primary and secondary productivity and a faster rate of succession from natural to higher seral stage (Khan and Ansari, 2005). Eutrophication can lead to harmful algal blooms, dead zones, and fish kills (Wurtsbaugh et al., 2019). The concentration of chlorophyll-a in water helps quantify phytoplankton levels, which can be used as an indicator to assess trophic status and water quality (Devercelli and Peruchet, 2008; Cunha et al., 2013).

In recent years, many studies observed the spatial and temporal distribution of chlorophyll-a and its relation with multiple environmental factors (Filazzola et al., 2020). Precipitation was predicted as an important environmental factor that affects chlorophyll-a concentration in lake water, among other environmental factors such as nitrogen and phosphorus concentrations, geographic location, and water temperature (Filazzola et al., 2020; Huang et al., 2022) However, little is known how precipitation (within a short temporal period) affects phytoplankton dynamics. Previously published studies typically report the relationship between phytoplankton concentrations and precipitation at monthly or annual scales (Wu et al., 2021; Huang et al., 2022), thus the finer temporal resolution often important to managers is not well understood. Furthermore, these studies typically use data generated from earth system modeling rather than on-the-ground measurements, limiting applicability to smaller, more dynamic bodies of water such as urban lakes.

In this study, our objective was to identify the fine-scale temporal relationship between chlorophyll-a concentration and precipitation based on *in situ* measurements in a tropical, urban lake. Two competing predictions were tested: precipitation and subsequent stormwater runoff 1) increase chlorophyll-a concentration through nutrient addition, or 2) decrease chlorophyll-a concentration through dilution.

Methodology

Site Description

Samarinda is the capital city of East Kalimantan Province, which is the wealthiest province in Indonesia due to revenue from oil and gas production. With a 2020 population density of 1,147 people/km^2 (BPS Kota Samarinda, 2020), Samarinda is highly urbanized and is the most developed part of the province. This increasing urbanization combined with other factors such as topography, climate, soil type, and limited runoff/drainage infrastructure, this city routinely suffers from flooding in lowland areas (Suryadi, 2020). One flood control measure implemented by city managers and administrators was the construction of urban lakes to catch and store stormwater runoff. Constructed in 2004, Air Hitam Lake has been used for both flood control as well as for recreation, is known to have occasional water quality issues (Hamdhani et al., 2023), and is the subject of our study. This urban lake has a total area of 60,500 m^2 and an estimated volume of 120,000 m^3 with a perimeter of 1,203 m. The surrounding area of the lake consists of a mixture of residentials and commercial buildings. Surrounding the lake are a concrete road, pedestrian walkway, and on most sides a 10-15m wide, vegetation buffer zone with grasses and trees. The maximum depth of the lake varies between 2-3 m in the middle, but is approximately 1 m deep near the perimeter. The city regularly dredges the lake to maintain storage capacity for flood control. This lake has no outlet, but there are two concrete inlets that convey runoff from the city, however, this inflow volume is unmeasured. Human organic waste from untreated sewage systems can also drain into the lake. Sewage inputs are unknown, but are assumed to vary in relation to precipitation and runoff.

Data collection

Chlorophyll-a concentration was measured *in situ* through the *in vivo* chlorophyll method using a fluorometer (FluoroSense™). This method has been tested effective for rapid chlorophyll-a monitoring (Hamdhani et al., 2021). This *in situ* application reduces potential chlorophyll-a concentration changes associated with the required time to transport and prepare the sample when using traditional extraction methods (Hamdhani et al., 2021).

Using the calibrated fluorometer, chlorophyll-a measurements were taken at five stations in the Air Hitam Lake (Fig. 1). At each station, surface water samples were collected from the top 20cm of the lake using a 1L container. Measurements were taken using the fluorometer in the sample container following protocols documented in

Hamdhani et al. (2021). Lake sampling occurred from October to December 2022 during the rainy season. Two measurements were taken per month. Due to potential diurnal variation in measured chlorophyll-a concentrations, sampling occurred consistently from 4:00 to 5:00pm in the afternoon. Precipitation was recorded using an electronic tipping bucket (Model WH0531) that was placed near the Air Hitam Lake, following standard rain-gauge installation protocols (Brooks et al., 1997). Concurrent with chlorophyll-a and precipitation measurements, several basic water quality parameters were also quantified: turbidity (SPER Scientific turbidity meter model 860040), dissolved oxygen (DO) (Apera Instruments AI480 DO850 probe), water temperature, pH, electric conductivity (EC), and total dissolved solids (TDS) (Apera Instruments SX823-B multiprobe). Phosphate was measured by collecting 750 ml water from each station, and transported immediately to the Water Quality Laboratory of the Faculty of Fisheries and Marine Science, Mulawarman University. Ascorbic acid method using a spectrophotometer (US-EPA., 1978) was applied to quantify phosphate (PO_4) concentration.

Data analysis

We measured the chlorophyll-a concentration and examine the relationship with total precipitation within the four days prior to sampling. The four-day precipitation accumulation was chosen based on two months of pre-monitoring using an installed meter scale for measuring lake depth. The result indicated that 5 or more days following precipitation, the water surface level of Air Hitam Lake returned to its normal surface level. Therefore, the 4-day period encompasses a stronger relationship with runoff. To test our hypotheses, we used linear regression analysis using statistical program R (version 3.5.1: R Core Team, 2019) to determine the trend and significance of precipitation (independent variable) in affecting chlorophyll-a concentration (dependent variable). Because turbidity and nutrient (phosphate) concentrations also impact chlorophyll-a levels, we also ran regressions with those as well.

Results and discussion

Basic water quality

Our water quality data presented in Table 1 showed that pH was high, ranging from 8.80-9.76, showing slightly alkaline conditions throughout our study period. This pH level is most likely impacted by the discharge of domestic wastewater which generally contains surfactant found in detergents or cleaning products (Bajpai 2007; Siyal et al., 2020). In Samarinda City, the discharged domestic wastewater into the city drainage system was untreated, consequently ending up in the nearby water bodies including the Air Hitam Lake. A similar tendency of high pH has been reported in urban water bodies receiving significant concentrations of domestic wastewater (Ustaoğlu et al., 2017; Al-Ani et al., 2022). The pH level in the lake was slightly above the optimal range of 6.5 to 8.5 to support sensitive aquatic life as suggested by the US-EPA (2013). However, lower pH values indicating acidity are typically more detrimental to aquatic biota than high pH values like those found in Air Hitam Lake. Zang et al. (2011) reported that the relationship between pH and chlorophyll-a was complex and sometimes inconclusive, in certain conditions such as at high chlorophyll-a concentration (>10µg/L), the correlation between the two was significantly positive.

Measured dissolved oxygen levels fluctuated widely between 3.79 to 16.63 mg/L. Persistent cloudy weather that occurred in the beginning of the study (including when the first two samples were taken) could be responsible for relatively low dissolved oxygen levels in the beginning compared to later samples. The weather on the other sampling days was relatively sunny, likely increasing photosynthesis rates and subsequent dissolved oxygen. Dissolved oxygen concentrations below 3 mg/L are of concern for most aquatic organisms (US-EPA, 2022). Photosynthetic activities by microalgae led to the production of large amounts of oxygen causing an increase in dissolved oxygen in the water. Under non-aquaculture waters with a chlorophyll-a concentration greater than 10 µg/L, Zang et al. (2011) reported a significant positive correlation between chlorophyll-a and dissolved oxygen. In our studied lake, we found that the average concentration of dissolved oxygen was mostly high; this might have resulted from corresponding photosynthetic activities, indicated by high chlorophyll-a concentrations. Although we did not sample at night, we expect that this algal driven dissolved oxygen levels would decrease dramatically when photosynthesis stopped and respiration began.

Water temperature ranged between 29.2 and 32.7ºC, indicating that the lake water should be capable support tropical, aquatic organisms, including microalgae. Singh and Singh (2015) observed that 20 to 30ºC is the optimum temperature for general microalgae species growth. In a temperate lake, Elliott et al. (2006) reported that elevated temperature contributed to the increase of phytoplankton biomass, however, nutrient loading was identified as the most prominent factor. Lake surface water temperature can be influenced by precipitation rate. Yang et al. (2021) reported that rate of precipitation was positively correlated with surface water temperature in an urban lake that drained majority impervious surfaces.

Total dissolved solids and electrical conductivity tolerance limits are usually not given for fish and other aquatic organisms, although they can be used as a water pollution indicator (Das et al., 2006; Pal et al., 2015). The values of our total dissolved solids and electrical conductivity measurements were typically lower than values reported in other urban tropical lakes (Sri Lanka: Weerasinghe and Handapangoda, 2019) but were very similar to those reported in Malaysia (Hossain and Mahmud, 2019).

Turbidity ranged between 29.1 and 79.3 NTU. The relationship between turbidity and chlorophyll-a concentration is complex. Decreased water clarity can limit sunlight penetration, which can result in photosynthesis limitations. Consequently, when microalgae are unable to carry out photosynthesis, chlorophyll-a concentrations can decrease (Irigoien and Castel, 1997). However, the concentration of chlorophyll-a in a lake can also impact turbidity. When the eutrophication level is high, this algal growth can contribute to increased turbidity, which can result in reduced water clarity (measured by secchi disk) (Gulati and Van Donk, 2002). It is important to understand that other factors can also influence the concentration of chlorophyll-a in water, such as nutrient availability and water temperature (Carrick et al., 1994). Therefore, while there may be a correlation between turbidity and chlorophyll-a, it is not always direct or consistent. The specific threshold for acceptable turbidity levels can vary depending on the intended use of the water body, such as drinking water, recreational activities, or aquatic biota habitat. In general, lower levels of turbidity are typically preferred as they indicate clearer and cleaner water. In Indonesia, there are no national turbidity limits for water quality, but turbidity is regulated in other countries, for example, Australia, Canada, and USA (Collins et al., 2011). Several publish studies suggest that considering allowable increases of turbidity in clearwater systems for fish and wildlife, no more than 25 NTU above natural in streams and no more than 5 NTU above natural in lakes (Lloyd, 1987; Collins et al., 2011). Turbidity levels in Air Hitam Lake were consistently higher than these levels.

Anthropogenic driven nutrient enrichment of lakes has profound impacts on phytoplankton blooms. In a hypereutrophic lake in Turkey (Çelik, 2006) reported that chlorophyll-a showed significant positive correlations with phosphate concentrations during rainy seasons. Similarly, in a Swedish lake warming period, there was a concurrent increase in both phosphate and chlorophyll-a levels (Pettersson et al., 2003). Phosphate concentration in Air Hitam Lake ranged between 0.052 and 0.246 mg/L. According to Indonesia water quality monitoring regulation (PP RI No. 2/2021), concentration of 0.1 mg/L phosphate is the upper threshold to conduct aquaculture in lentic system.

Chlorophyll-a is one of the essential component in determining lake trophic status. The trophic state of aquatic ecosystems provides crucial information, as it indicates the relative health of the water body including the impact of human activity on water quality and the ecological processes of water bodies, including lakes, and reservoirs. Trophic state indices are useful in understanding phytoplankton development, which are indicated by chlorophyll-a concentration and are typically governed by the availability of nutrients and light (Carlson, 1977). Moreover, Mehner et al. (2005) reported that level of chlorophyll-a concentration is an important factor to determine fish community composition, in addition to maximum and mean depth and volume of German lakes. In tropical regions, a concentration of 10.1 µg/L and above indicates that lake or reservoir is in eutrophic state (Cunha et al., 2013). In our sampling of Air Hitam Lake, the chlorophyll-a concentration ranged between 18.6 and 116.67 µg/L indicating that it was consistently eutrophic.

Chlorophyll-a response

According to the result, chlorophyll-a in the water showed a significant negative correlation with the total precipitation ($r^2=0.71, p=0.035$) (Fig. 3A), meaning that the increase in the total precipitation resulted in a chlorophyll-a concentration decrease. We posit that mechanism at play here is dilution. This result is in line with the relationship between chlorophyll-a and precipitation reported by Jeong et al. (2011), who observed that summer rainfall had suppressed the high concentration of chlorophyll-a in a regulated river. However, Huang et al. (2022) reported the opposite in Chinese lakes: chlorophyll-a concentration in water was positively correlated with monthly precipitation. Positive relationships between precipitation and chlorophyll-a are assumed to be driven by the scouring effect of runoff, which transports nutrients from soils (mainly phosphorus) to lakes (Carpenter et al., 1998; Ekholm et al., 2012). In fact, mineral iron in the soil may also play an indirect effect on chlorophyll-a concentration by regulating nutrient contents such as phosphorus in the lake water (Tang et al., 2019). Interestingly, we observed that increases in total precipitation resulted in lower phosphate concentration (Fig. 2). This relationship between total precipitation and phosphate concentration helps explain why chlorophyll-a concentration responded negatively toward total precipitation (Fig. 3A) as phosphate concentration is typically positively correlated with chlorophyll-a production as seen in this study (Fig. 3C), although the regression was not significant ($r^2=0.59, p=0.072$). Tang et al. (2019) reported that intense rainfall can decrease the time water stays in a particular water body and increase water movement, which can lead to a decrease in the concentration of phosphorus in the water.

In the area surrounding Air Hitam Lake, there are no specific activities, other than wastewater discharge, that potentially contribute to the addition of high nutrient contents in runoff (i.e. no industrial activities, urban agriculture, city slaughterhouse, etc.). Direct stormwater runoff to the lake potentially discharge larger amounts of nutrients from soils and eventually could elevate algae growth (Huang et al., 2022). Our result suggests that inflows from the inlets and direct stormwater runoff post four-day precipitation carried too little nutrients to increase the chlorophyll-a concentration in that time period. Municipal infrastructure in Samarinda City is not fully developed, and many stretches of drainage systems, for runoff and sewage, are not lined. As a result, infiltration rates are expected to be higher compared to concrete lined or piped conveyance systems. Consequently, under normal conditions, very little if any sewage discharges into Air Hitam Lake. However, during rainy periods, we observed that sewage inflows into the lake typically increased with heavy runoff. Despite increases in sewage input, we did not observe predictable, corresponding changes in measured nutrient concentrations (Fig. 2). Similar to chlorophyll-a concentrations, we suspect this was also due to dilution.

Turbidity can create a shadowing effect that can reduce photosynthesis and retard algal growth as well as chlorophyll-a concentration (Wang, 1974; Park and Kang, 2006), so we also tested the relationship between turbidity and chlorophyll-a concentration (Table 1 and Fig. 3B). Interestingly, it resulted a positive correlation between the two variables ($r=0.79$, $p=0.063$), however, the correlation was not significant. Using an identical probe, Hamdhani et al. (2021) observe similar positive trend between turbidity and chlorophyll-a concentration. Moreover, Fig. 2 shows that the accumulated rainfall had a negative trend toward turbidity, indicating that stormwater runoff carried relatively little soil (silt) particles. In this case, the precipitation runoff increased the water dilution and likely suppressing turbidity levels, similar to phosphate and chlorophyll-a concentration.

Overall, precipitation was the only significant predictor for chlorophyll-a (Table 2). The dilution from precipitation runoff likely plays an important role in Air Hitam Lake and other tropical, urban lakes, demonstrating that variations in chlorophyll-a concentration were likely affected more by dilution than by other factors. For example, the highest average of chlorophyll-a, turbidity, and phosphate levels were observed when there was zero accumulated precipitation (Figure 2). The roles of precipitation to improve water quality by diluting substance concentration in lentic systems have also been reported in other studies (Moses et al., 2011; Wu et al., 2017; Han and Bu, 2023). Finally, our findings indicate that in tropical, urban lakes, intense precipitation and resulting stormwater runoff can moderate eutrophication. This knowledge also can help managers appropriately time water quality measurements to better reflect the conditions of tropical, urban lakes.

Conclusion

In this study, the short-term relation between chlorophyll-a and the total precipitation was investigated. In the tropical urban constructed lake, we found that recent, total precipitation resulted in a significant negative correlation with the concentration of the chlorophyll-a. Our investigation indicated that although runoff increases connectivity between sewage discharge and Air Hitam Lake, the resulting nutrient loading and silt loading was relatively small. Furthermore, our findings suggest that total precipitation elevated lake water dilution, thus decreasing chlorophyll-a concentration.

Our data indicates that monitoring of chlorophyll-a in urban lakes following recent precipitation and runoff likely underestimates the normal chlorophyll-a concentration present in the system. This underestimation has implications for managers who monitor lakes for eutrophication in accordance with ecological and recreational goals and guidelines. Although the trends observed in Air Hitam Lake appear to mirror those from other tropical urban lakes, additional research can help fine tune our understanding of these relationships. Additional research should examine other environmental factors under a variety of conditions such as longer-term scenarios that might encompass any delayed effects from runoff as well as different lake sizes and types of lake construction.

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Table 1 Water quality data from Air Hitam Lake from sampling on October 24, 2022 to December 12, 2022. Mean, maximum, and minimum values are reported.

		Date					
Parameters		24-Oct	31-Oct	7-Nov	21-Nov	5-Dec	12-Dec
pH	Mean	9.05	9.30	9.31	9.17	9.57	9.62
	Min	8.80	9.26	9.04	8.90	9.15	9.45
	Max	9.34	9.39	9.47	9.40	9.76	9.75
Dissolved Oxygen	Mean	4.41	5.53	10.85	10.03	11.80	13.48
(mg/L)	Min	3.79	4.85	8.90	9.36	9.61	11.20
	Max	5.00	6.35	12.63	11.44	13.10	16.63
Temperature (°C)	Mean	30.3	30.8	29.5	31.1	30.6	30.1
	Min	29.3	30.3	29.2	29.6	30.0	30.0
	Max	31.5	31.3	29.8	32.7	31.1	30.3
Total Dissolved Solids	Mean	146.00	159.40	172.20	151.00	173.80	180.60
(ppm)	Min	145	158	171	146	172	179
	Max	147	161	173	158	176	182
	Mean	292.20	318.80	345.00	301.80	347.80	362.00
Conductivity (µS/cm)	Min	290	317	341	291	343	359
	Max	295	322	347	315	351	365
Turbidity (NTU)	Mean	40.00	53.08	65.19	33.24	42.61	38.39
	Min	34.70	43.78	53.00	29.10	33.90	36.70
	Max	44.58	70.66	79.30	37.40	54.60	40.23
Phosphate (mg/L)	Mean	0.069	0.073	0.166	0.075	0.125	0.205
	Min	0.052	0.059	0.137	0.052	0.106	0.070
	Max	0.085	0.091	0.246	0.096	0.155	0.670
Chlorophyll-a (µg/L)	Mean	27.31	41.60	57.39	19.80	44.36	45.00
	Min	23.33	23.33	26.30	18.60	33.60	36.60
	Max	31.60	62.33	116.67	21.60	56.60	55.60
Total 4-day Precipitation (mm)		16.80	5.70	0.30	11.70	0.90	7.40

Table 2 Summary of linear regression for total 4-day precipitation (mm), turbidity (NTU), and phosphate (mg/L) predictors with chlorophyll-a concentration in Air Hitam Lake. Results include beta estimates (Estimates), confidence interval (CI), R^2, adjusted R^2, and p-value. Bold indicates significant p-values with alpha<0.05

Predictors	Estimates	CI	R^2	R^2 adjusted	p-value
(Intercept)	52.02	37.37 – 66.68	0.709	0.636	**0.001**
Precipitation	-1.79	-3.39 – -0.20			**0.035**
(Intercept)	-2.12	-48.24 – 44.00	0.621	0.526	0.905
Turbidity	0.91	-0.08 – 1.90			0.063
(Intercept)	12.57	-19.89 – 45.04	0.595	0.493	0.343
Phosphate	269.88	-39.51 – 579.27			0.073

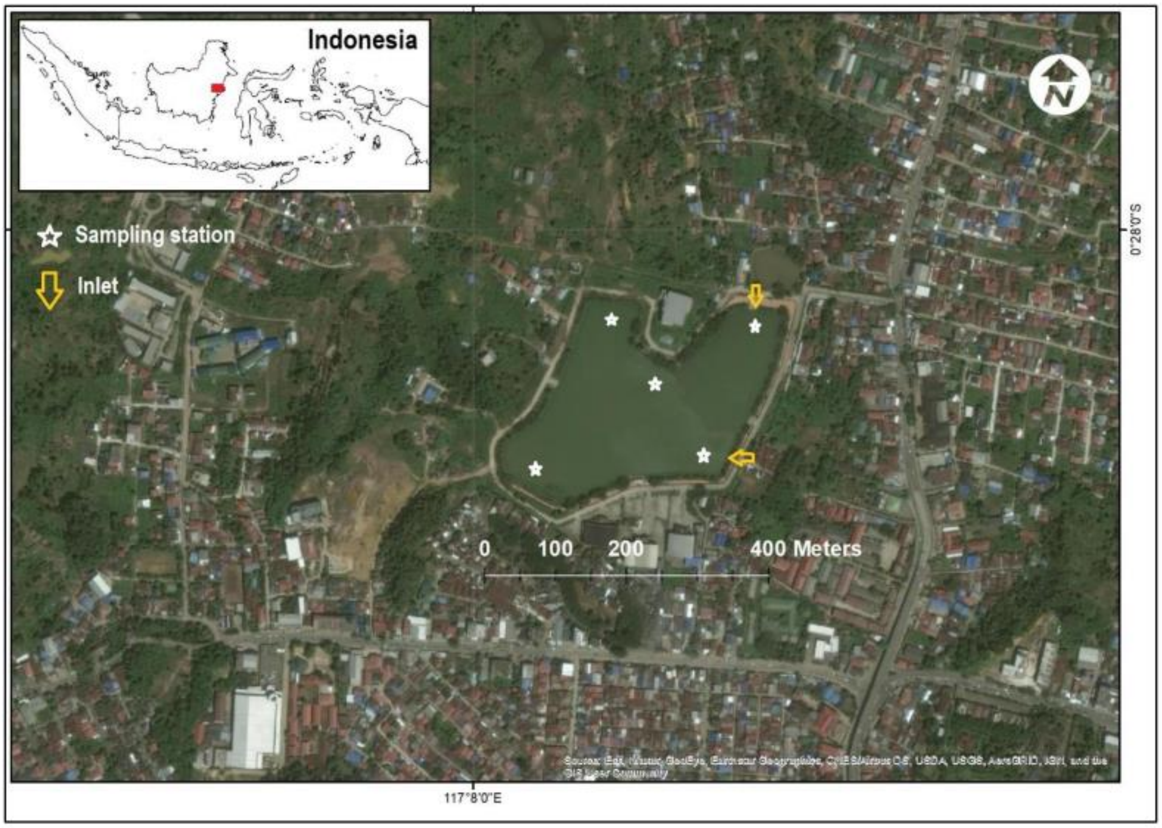

Figure 1 Map showing Air Hitam Lake study site in Samarinda City, Indonesia with five sampling stations denotes by white stars and two inlets denoted by yellow arrows.

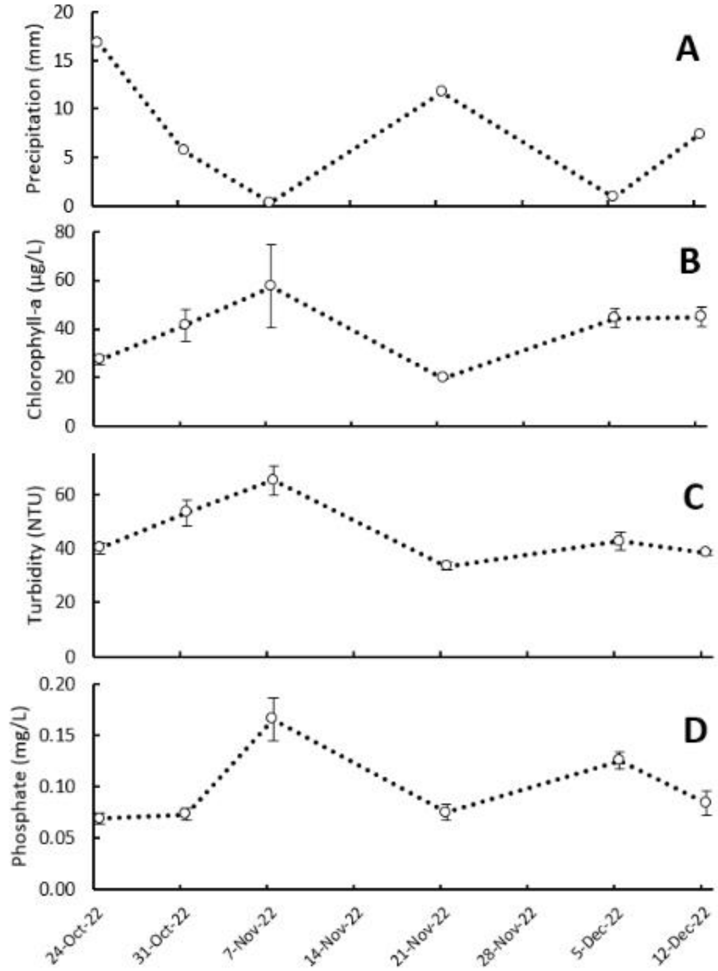

Figure 2 Plots illustrating A) 4-day total precipitation (mm) and B) average chlorophyll-a concentration (µg/L), C) turbidity (NTU), and D) phosphate concentration (mg/L) from five stations at Air Hitam Lake. Error bars indicate the Standard Error.

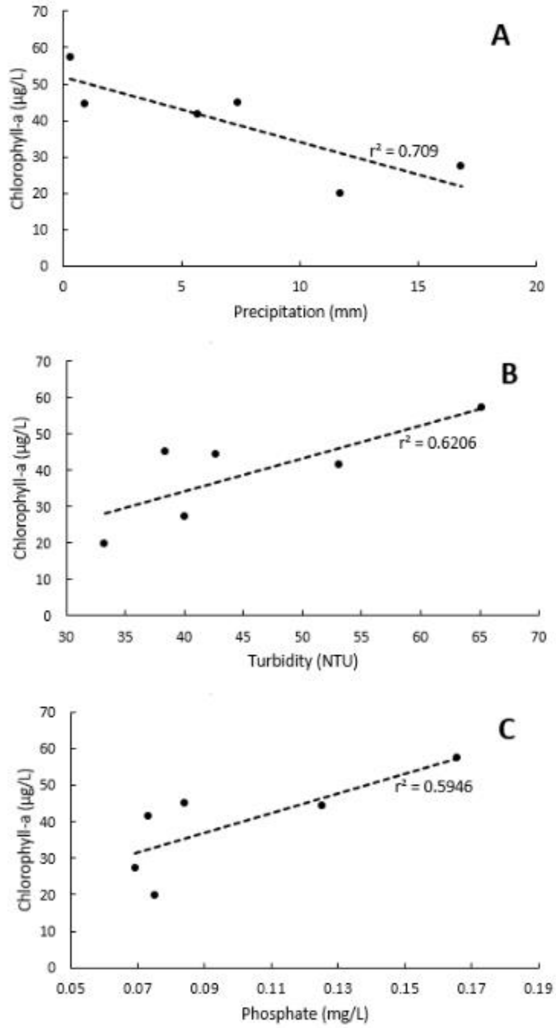

Figure 3 Scatter plots showing the relationship between Air Hitam Lake mean chlorophyll-a concentration (µg/L) with A) 4-day total precipitation (mm), B) mean turbidity (NTU), and C) mean phosphate concentration (µg/L). Dashed black line denotes the line of best fit.

2	Notifikasi Revisi 1	11 Agustus 2023	**a) Email konfirmasi dan korespondensi dengan co-author** **b) Laman Revisi 1 di akun jurnal**

a. **Email konfirmasi dan korespondensi dengan co-author**

5/3/26, 10:40 PM Universitas Mulawarman Mail - Lakes & Reservoirs: Science, Policy and Management for Sustainable Use - Decision on Manuscrip…

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

Lakes & Reservoirs: Science, Policy and Management for Sustainable Use - Decision on Manuscript ID LRE-23-024

9 messages

LRE EO Temp <onbehalfof@manuscriptcentral.com> Sat, Aug 12, 2023 at 11:03 AM
Reply-To: lre.eo@wiley.com
To: hamdhani@fpik.unmul.ac.id
Cc: lre.eo@wiley.com

11-Aug-2023

Dear Dr. Hamdhani:

Manuscript ID: # LRE-23-024 Title: "Chlorophyll-a variation in response to precipitation in a tropical urban lake"

Thank you for submitting your manuscript to Lakes and Reservoirs: Research and Management. Your paper has been assessed by the editor and reviewed independently.

After careful deliberation, it has been concluded that your manuscript is not suitable in its present form for publication in the Journal.

Among the review comments was that lake water quality depends on many other factors, other than precipitation alone, and that the Introduction needs better justification as to why precipitation might lead to changes in algal biomass, and why urban lakes might respond differently to precipitation than other lakes. It also was questioned whether or not the study lake was representative of many tropical urban lakes. Focusing on six sampling events within a single two-month period also was questioned, suggesting the sampling timing may not be representative of a temporally dynamic system. The need to take dilution effects related to precipitation events, and how they might influence both nutrient and phytoplankton concentrations requires further discussion. Additional review comments are provided below.

Please substantially revise your manuscript to appropriately address the review comments. You can then submit the revised manuscript for further publication consideration. If you choose to do so, please also clearly indicate how you addressed each review comment (e.g., different font style or color).

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Should you be interested, Wiley Editing Services offers expert help with manuscript, language, and format editing, along with other article preparation services. You can learn more about this service option at www.wileyauthors.com/eeo/preparation. You can also check out Wiley's collection of free article preparation resources for general guidance about writing and preparing your manuscript at www.wileyauthors.com/eeo/prepresources.

For your reference, the comments of the reviewer(s) are included at the end of this email.

Yours sincerely,

Prof. Walter Rast (Editor-in-Chief)
Lakes & Reservoirs: Science, Policy and Management for Sustainable Use

Reviewer(s)' Comments to Author:
Reviewer: 1

Comments to the Author
General comments

This study analyzed the relationship between chlorophyll-a and precipitation for a tropical urban lake in Indonesia. Precipitation is certainly one factor affecting lake water quality, but the connection is somewhat indirect and depends on many other factors (nutrient availability in the lake, nutrient concentration of runoff, etc.). The introduction makes the case that we don't have a good understanding of this relationship, especially for small urban lakes, but it could do a better job explaining why precipitation might lead to changes in algal biomass, and why urban lakes might respond differently to

https://mail.google.com/mail/u/3/?ik=35ace941da&view=pt&search=all&permthid=thread-f:1773990765074456609&simpl=msg-f:17739907650744566… 1/5 precipitation than other lakes.

Moreover, the authors should provide justification for using this lake as a case study. Is it likely to be representative of many tropical urban lakes? Or is it likely that each lake would have unique relationships between precipitation and chlorophyll?

The data presented here are from 6 sampling events within a 2-month period in 2022. As such, it is difficult to tease apart any general relationships for this lake from, for example, normal seasonal trends. The conclusion that timing of sampling matters seems trivial in a temporally dynamic system.

Specific comments:
Line 30: Is it worth listing these “basic water quality parameters”?
Lines 45-54: This connection between urban stream syndrome and urban lakes needs to be better developed. Explain how changes in hydrology and geomorphology of urban streams might affect water quality in urban lakes. Also, in many cities streams have been buried and are part of the stormwater infrastructure, which may drain directly into urban lakes. So whether or not an urban lake is fed by surficial streams may be an important factor in processing incoming nutrients.
Line 65: Explain why runoff on impervious surfaces results in water coming into contact with human organic waste. This would probably vary across different cities, depending on wastewater infrastructure.
Lines 98-100: I like that the authors present alternative hypotheses, but these are not really competing—both could certainly be true, albeit at slightly different timescales.
Line 119: No outlet—is evaporation sufficient to prevent overflow? Or is the lake designed for infiltration/groundwater recharge?
Lines 148-153: The four-day rainfall window is based on hydrology (lake levels being elevated for up to four days following rain events), but it doesn’t take into account temporal dynamics of phytoplankton growth. I wonder how that effects the analysis.
Lines 156-158: Turbidity could affect algal growth if due to sediment inputs, for example, but phytoplankton may also account for much of the turbidity.
Line 176: It would be good to also report DO as % saturation.
Line 221: “published”
Lines 247-250: You could take this analysis one step further. How much did chlorophyll concentrations decrease on average? Does the amount of dilution (relative increase in lake water volume) fully account for this decrease?
Line 254: Monthly precipitation is a very different temporal resolution, and probably is not a good comparison.
Line 260: If untreated sewage is entering the lake with stormwater runoff, that phosphorus would be primarily in organic form and would require time to mineralize and lead to increased dissolved PO4.

Reviewer: 2

Comments to the Author
Major suggestions:
Interesting study, some comments below.
The main finding of this study is that precipitation more than nutrients influence the variation of chlorophyll-a concentrations in Air Hitam Lake. It is likely that this phenomenon may or may not be observed in other urban water bodies. Importantly, maximum levels of nutrients can be set during periods of low rainfall. Therefore, the abstract and manuscript can be finished with a recommendation to take into account dilution effects when studying and managing aquatic ecosystems at the areas with abundant precipitation, not only further studies.
Table 2 demonstrates high enough correlation between chl-a and phosphate concentrations. This relationship was not statistically sufficient because of the low number of the observations as mean values from 5 sampling stations were used. But if the observations from each station would be used this relation will be statistically sufficient. Precipitation influences concentrations of both phosphate and chl-a in the same way (Table 1). Thus decrease of nutrient concentration by dilution can be a reason for phytoplankton (chl-a) decreased abundance too.
Line 199. It can be added that in this study weak relation is observed between precipitation amounts and temperature.

Minor.
Line 65. larger amounts of nutrients
Line 101. Replace "Methodology" with "Methods and materials".
Page 23, Move "Conductivity" from the line 31 to line 29.

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Sun, Aug 13, 2023 at 11:10 PM
To: Drew Eppehimer <deppehimer@gmail.com>, "Eppehimer, Drew Elliot - (deppehimer)" <deppehimer@arizona.edu>

Hi Drew,

Finally we have got a response from the Journal of Lakes & Reservoirs: Science, Policy and Management for Sustainable Use.
The good news, it is not rejected, so we have a chance to revise it. I am very excited about this.

Can we have a brief zoom meeting today or tomorrow, or the time that works for you?
This time, morning Tucson time (6am-9am) is good for me.
Please let me know ;-)

The attached file is the initial submitted version.

Thank you,
[Quoted text hidden]

Hamdhani et al 2023-Manuscript.docx
646K

Drew Eppehimer <deppehimer@gmail.com> Mon, Aug 14, 2023 at 3:28 AM
To: Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

Great news!

hmmmm let me look over all this

maybe tomorrow Monday Aug14th at 8:30am arizona time?
[Quoted text hidden]

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Mon, Aug 14, 2023 at 2:31 PM
To: Drew Eppehimer <deppehimer@gmail.com>

Sounds good, talk to you then.
Thank you Drew

FPIK UNMUL is inviting you to a scheduled Zoom meeting.

Topic: FPIK UNMUL"s Ruang Rapat Pribadi

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Drew Eppehimer <deppehimer@gmail.com> Mon, Aug 14, 2023 at 11:32 PM
To: Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

having trouble getting zoom to work

can we try google meet?
[Quoted text hidden]

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Mon, Aug 14, 2023 at 11:33 PM
To: Drew Eppehimer <deppehimer@gmail.com>

Sure, no problem.
[Quoted text hidden]

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Mon, Aug 14, 2023 at 11:34 PM
To: Drew Eppehimer <deppehimer@gmail.com>

https://meet.google.com/tqg-zmrj-tfp

On Mon, Aug 14, 2023 at 11:33 PM Drew Eppehimer <deppehimer@gmail.com> wrote:
[Quoted text hidden]

Drew Eppehimer <deppehimer@gmail.com> Mon, Aug 14, 2023 at 11:34 PM
To: Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

Great, thank you. Just send the invite and I'll hop on
[Quoted text hidden]

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Fri, Aug 18, 2023 at 12:21 AM
To: Drew Eppehimer <deppehimer@gmail.com>

Hi Drew,

Here is my revision, plus the response to the reviewers.
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Abstract

With increasing urbanization, urban lakes are becoming more common and serve as important flood control infrastructure, recreational uses, as well as habitat for a variety of biota. However, given their construction, function, and location, urban lakes are susceptible to disturbances including stormwater runoff from metropolitan catchment areas. For example, nutrient loading from stormwater runoff can cause eutrophication. Chlorophyll-a concentration is an important water quality parameter because it is used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. In this study, we examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. From October through December 2022, chlorophyll-a, turbidity, phosphate (PO_4), pH, dissolved oxygen, temperature, total dissolved solids, and conductivity were measured at five stations in Air Hitam Lake, and precipitation was measured adjacent to the lake. These data indicated that chlorophyll-a concentrations were negatively correlated with recent precipitation ($r^2=0.71$, $p<0.05$). This relationship was likely a result of dilution from increased lake volume. Although urban runoff is expected to increase nutrient loading, our monitoring indicated that dilution can mediate this process in the short-term. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations due to dilution. As a result, dilution effects should be examined when studying and managing urban lentic ecosystems with strong precipitation dynamics. Further studies are necessary to better

understand these urban aquatic ecosystems to continue to improve future management efforts.

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1

Chlorophyll-a variation in response to precipitation in a tropical urban lake

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Abstract

With increasing urbanization, urban lakes are becoming more common and serve as important flood control infrastructure, recreational uses, as well as habitat for a variety of biota. However, given their construction, function, and location, urban lakes are susceptible to disturbances including stormwater runoff from metropolitan catchment areas. For example, nutrient loading from stormwater runoff can cause eutrophication. Chlorophyll-a concentration is an important water quality parameter because it can be used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. In this study, we examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. ~~Chlorophyll-a, precipitation, and several basic water quality parameters were sampled at five stations during the 2022 rainy season~~. From October through December 2022, chlorophyll-a, turbidity, phosphate (PO_4), pH, dissolved oxygen, temperature, total dissolved solids, and conductivity were measured at five stations in Air Hitam Lake, and precipitation was measured adjacent to the lake. ~~The~~ These data indicate that chlorophyll-a concentrations are negatively correlated with recent precipitation ($r^2=0.71$, $p<0.05$). This relationship is likely a result of dilution from increased lake volume. Although urban runoff is expected to increase nutrient loading, our monitoring indicates that dilution can mediate this process. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations due to dilution. As a result, dilution effects should be examined when studying and managing urban lentic ecosystems with strong precipitation dynamics. ~~Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations~~. Further studies are necessary to better understand these urban aquatic ecosystems to continue to improve future management efforts.

Keywords: chlorophyll-a, precipitation, lake, lentic, Samarinda, Kalimantan, Indonesia

Introduction

The world is becoming increasingly urbanized resulting in a myriad of effects on ecosystems (Elmqvist et al., 2013). Concomitant with increases in urbanization are increases in the abundance of urban water bodies (Strokal et al., 2021). Urban water bodies, both lentic and lotic, are characterized by higher influence from anthropogenic activities and as a result have altered ecosystems that may require different monitoring standards than natural systems (Schueler dan Simpson, 2001; Naselli-Flores, 2008). Consistent patterns of alterations that occur in urbanized streams/rivers have been identified by Walsh et al. (2005) and defined as the "urban stream syndrome", whose characteristics include a flashier hydrograph, altered channel morphology and stability, and elevated concentrations of nutrients and contaminations. A multitude of sources within urban watersheds, including municipal wastewater discharges, malfunctioning septic systems, and sewage overflows, contribute to secondary nutrient loading in urban streams (Naselli-Flores, 2008). These urban stream syndrome characteristics have frequently been documented in temperate regions but are also likely to occur in tropical regions and in different types of water bodies, including lakes (Yule et al., 2015; Lee et al., 2019).

Compared to lakes in subtropical and temperate regions, lakes in tropical areas are characterized by high and frequent precipitation, which subsequently increases the intensity of runoff entering the lakes (Alemu et al., 2020). This addition of water volume from precipitation runoff can also increase the dilution of various dissolved substances in the lake (Moses et al., 2015). In tropical regions, elevated solar radiation also plays a significant in lake dynamics. The air temperature in tropical regions relatively remains high throughout the year and affects the lake's surface water temperature and evaporation rate (Talling, 2001; Alemu et al., 2020; de Farias Mesquita et al., 2020). In an African natural non-urban tropical lake, Rooney et al. (2018) reported that on days with precipitation, the lake water volume increased rapidly, and the surface water temperature of the lake decreased. However, Yang et al. (2021) reported that rate of precipitation was positively correlated with surface water temperature in an urban lake that drained majority impervious surfaces. These results show that urban lakes can have different temperature and precipitation responses than natural lakes. Water temperature is an important factor in various metabolic processes in water bodies, including photosynthesis occurring in aquatic plants, algae, and various types of bacteria in the water (Lewis, 2010).

Urban lakes differ from natural lakes in a number of ways. For example, they are usually smaller and shallower, and the majority are man-made, also known as constructed lakes (Schueler dan Simpson, 2001). As constructed lakes, their water bodies tend to have geometric shapes and often function as flood control infrastructure, water storage, and/or for recreational uses (Naselli-Flores, 2008). These constructed lakes often have area/drainage area of at least 10:1, meaning that the catchment area strongly influences the lake (Schueler dan Simpson, 2001). The rainfall-discharge variation in the catchment area drives water quality dynamics in corresponding water bodies (Jakeman and Hornberger, 1993), and this relationship is more pronounced in urban lentic systems. Because urban stormwater runoff typically originates from impervious surfaces and often comes into contact with human organic waste, it can collect larger amount of nutrients than runoff in less developed areas (Miller et al., 2014). The situation varies among different cities worldwide, as it is largely contingent upon the presence of stormwater and wastewater infrastructure. A significant number of urban areas globally suffer from inadequate or absence of wastewater infrastructure (Hamdhani et al., 2020). Even developed cities face problems associated with increased nutrient loading. For example, in an urban lake in London, United Kingdom, Birch and McCaskie (1999) found that inputs from River Thames increased phosphates resulting in eutrophication. Across the globe, from developing to fully developed nations, urbanization has resulted in large scale watershed changes to both rivers and lakes (Schueler dan Simpson, 2001). Because they often function as retention rather than flow conveyance, urban lakes are typically more sensitive to nitrogen and phosphorus loading from stormwater runoff than rivers or streams (Kakade et al., 2021). Therefore, water quality changes resulting from this nutrient loading can be a concern for managers, especially when the urban lake is used for recreation or water storage for consumptive use. Increases in urban development can result in nutrient loading that promotes rapid algal growth, destabilizes ecological balance, and impairs lake water quality (Qin et al., 2013; Alprol et al., 2021), which could not only exceed thresholds for aquatic biota but might also exceed health standards for humans.

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that carbon dioxide in order to live and grow. The excessive growth of phytoplankton due to nutrient enrichment can lead to eutrophication, which is the condition of imbalanced primary and secondary productivity and a faster rate of succession from natural to higher seral stage (Khan and Ansari, 2005). Eutrophication can lead to harmful algal blooms, dead zones, and fish kills (Wurtsbaugh et al., 2019). The concentration of chlorophyll-a in water helps quantify phytoplankton levels, which can be used as an indicator to assess trophic status and water quality (Devercelli and Peruchet, 2008; Cunha et al., 2013).

In recent years, many studies observed the spatial and temporal distribution of chlorophyll-a and its relation with multiple environmental factors (Filazzola et al., 2020). Precipitation was predicted as an important environmental factor that affects chlorophyll-a concentration in lake water, among other environmental factors such as nitrogen and phosphorus concentrations, geographic location, and water temperature (Filazzola et al., 2020; Huang et al., 2022). Precipitation potentially can influence the concentration of chlorophyll-a in water through dilution mechanisms that cause a decrease in chlorophyll-a and nutrient concentrations (Moses et al., 2015), and conversely, it can also increase chlorophyll-a concentrations through increased nutrient loading from runoff (Silva et al., 2019). Therefore, we assume that urban lakes can respond very differently to precipitation depending on context. This depends on the characteristics of the urban lake, such as its size, water source, catchment area, and the pollution level in this area.

~~However, l~~Little is known how precipitation (within a short temporal period) affects phytoplankton dynamics. Previously published studies typically report the relationship between phytoplankton concentrations and precipitation at monthly or annual scales (Tonetta et al., 2017; Wu et al., 2021; Huang et al., 2022), thus the finer temporal resolution often important to managers is not well understood. Furthermore, these studies typically use data generated from earth system modeling rather than on-the-ground measurements, limiting applicability to smaller, more dynamic bodies of water such as urban lakes.

In this study, our objective was to identify the fine-scale temporal relationship between chlorophyll-a concentration and precipitation based on *in situ* measurements in a tropical, urban lake. Air Hitam Lake, a man-made, urban lake located in Samarinda City, East Kalimantan, Indonesia, was chosen as a case study as it is relatively small and shallow, is fed primarily by stormwater runoff, and is located in the middle of the city, which is representative of many urban lakes in tropical regions. Two ~~competing~~ predictions were tested: precipitation and subsequent stormwater runoff 1) increase chlorophyll-a concentration through nutrient addition, or 2) decrease chlorophyll-a concentration through dilution.

Methods and materials~~Methodology~~

Site Description

Samarinda is the capital city of East Kalimantan Province, which is the wealthiest province in Indonesia due to revenue from oil and gas production. With a 2020 population density of 1,147 people/km^2 (BPS Kota Samarinda, 2020), Samarinda is highly urbanized and is the most developed part of the province. This increasing urbanization combined with other factors such as topography, climate, soil type, and limited runoff/drainage infrastructure, this city routinely suffers from flooding in lowland areas (Suryadi, 2020). One flood control measure implemented by city managers and administrators was the construction of urban lakes to catch and store stormwater runoff. Constructed in 2004, Air Hitam Lake has been used for both flood control as well as for recreation, is known to have occasional water quality issues (Hamdhani et al., 2023), and is the subject of our study. This urban lake has a total area of 60,500 m^2 and an estimated volume of 120,000 m^3 with a perimeter of 1,203 m. The surrounding area of the lake consists of a mixture of residentials and commercial buildings. Surrounding the lake are a concrete road, pedestrian walkway, and on most sides a 10-15m wide, vegetation buffer zone with grasses and trees. The maximum depth of the lake varies between 2-3 m in the middle, but is approximately 1 m deep near the perimeter. The city regularly dredges the lake to maintain storage capacity for flood control. This lake has no outlet, but there are two concrete inlets that convey runoff from the city, however, this inflow volume is unmeasured. Human organic waste from untreated sewage systems can also drain into the lake. Sewage inputs are unknown, but are assumed to vary in relation to precipitation and runoff.

Data collection

Chlorophyll-a concentration was measured *in situ* through the *in vivo* chlorophyll method using a fluorometer (FluoroSense™). This method has been tested effective for rapid chlorophyll-a monitoring (Hamdhani et al., 2021). This *in situ* application reduces potential chlorophyll-a concentration changes associated with the required time to transport and prepare the sample when using traditional extraction methods (Hamdhani et al., 2021).

Using the calibrated fluorometer, chlorophyll-a measurements were taken at five stations in the Air Hitam Lake (Fig. 1). At each station, surface water samples were collected from the top 20cm of the lake using a 1L container. Measurements were taken using the fluorometer in the sample container following protocols documented in Hamdhani et al. (2021). Lake sampling occurred from October to December 2022 during the period technically considered the "wet season"; however, Kalimantan/Borneo Island does not have a pronounced wet/dry season as is characteristic in the rest of the Indonesia archipelago (Cleary, 2011). As a result, this characteristic allowed our limited (3-month) sampling period to be representative of the year-round tropical climate conditions. ~~Lake sampling occurred from October to December 2022 during the rainy season.~~ Two measurements were taken per month. Due to potential diurnal variation in measured chlorophyll-a concentrations, sampling occurred consistently from 4:00 to 5:00pm in the afternoon. Precipitation was recorded using an electronic tipping bucket (Model WH0531) that was placed near the Air Hitam Lake, following standard rain-gauge installation protocols (Brooks et al., 1997). Concurrent with chlorophyll-a and precipitation measurements, several basic water quality parameters were also quantified: turbidity (SPER Scientific turbidity meter model 860040), dissolved oxygen (DO) (Apera Instruments AI480 DO850 probe), water temperature, pH, electric conductivity (EC), and total dissolved solids (TDS) (Apera Instruments SX823-B multiprobe). Phosphate was measured by collecting 750 ml water from each station, and transported immediately to the Water Quality Laboratory of the Faculty of Fisheries and Marine Science, Mulawarman University. Ascorbic acid method using a spectrophotometer (US-EPA., 1978) was applied to quantify phosphate (PO_4) concentration.

Data analysis

We measured the chlorophyll-a concentration and examine the relationship with total precipitation within the four days prior to sampling. The four-day precipitation accumulation was chosen based on two months of pre-monitoring using an installed meter scale for measuring lake depth. The result indicated that 5 or more days following precipitation, the water surface level of Air Hitam Lake returned to its normal surface level.

Therefore, the 4-day period encompasses a stronger relationship with runoff. To test our hypotheses, we used linear regression analysis using statistical program R (version 3.5.1: R Core Team, 2019) to determine the trend and significance of precipitation (independent variable) in affecting chlorophyll-a concentration (dependent variable). Because turbidity and nutrient (phosphate) concentrations also impact chlorophyll-a levels and vice versa, we also ran regressions with those as well.

Results and discussion

Basic water quality

Our water quality data presented in Table 1 showed that pH was high, ranging from 8.80-9.76, showing slightly alkaline conditions throughout our study period. This pH level is most likely impacted by the discharge of domestic wastewater which generally contains surfactant found in detergents or cleaning products (Bajpai 2007; Siyal et al., 2020). In Samarinda City, the discharged domestic wastewater into the city drainage system was untreated, consequently ending up in the nearby water bodies including the Air Hitam Lake. A similar tendency of high pH has been reported in urban water bodies receiving significant concentrations of domestic wastewater (Ustaoğlu et al., 2017; Al-Ani et al., 2022). The pH level in the lake was slightly above the optimal range of 6.5 to 8.5 to support sensitive aquatic life as suggested by the US-EPA (2013). However, lower pH values indicating acidity are typically more detrimental to aquatic biota than high pH values like those found in Air Hitam Lake. Zang et al. (2011) reported that the relationship between pH and chlorophyll-a was complex and sometimes inconclusive, in certain conditions such as at high chlorophyll-a concentration (>10µg/L), the correlation between the two was significantly positive.

Measured dissolved oxygen levels fluctuated widely between 3.79 to 16.63 mg/L. Persistent cloudy weather that occurred in the beginning of the study (including when the first two samples were taken) could be responsible for relatively low dissolved oxygen levels in the beginning compared to later samples. The weather on the other sampling days was relatively sunny, likely increasing photosynthesis rates and subsequent dissolved oxygen. Dissolved oxygen concentrations below 3 mg/L are of concern for most aquatic organisms (US-EPA, 2022). Photosynthetic activities by microalgae led to the production of large amounts of oxygen causing an increase in dissolved oxygen in the water. Under non-aquaculture waters with a chlorophyll-a concentration greater than 10 µg/L, Zang et al. (2011) reported a significant positive correlation between chlorophyll-a and dissolved oxygen. In our studied lake, we found that the average concentration of dissolved oxygen was mostly high; this might have resulted from corresponding photosynthetic activities, indicated by high chlorophyll-a concentrations. Although we did not sample at night, we expect that this algal driven dissolved oxygen levels would decrease dramatically when photosynthesis stopped and respiration began.

Water temperature ranged between 29.2 and 32.7ºC, indicating that the lake water should be capable support tropical, aquatic organisms, including microalgae. Singh and Singh (2015) observed that 20 to 30ºC is the optimum temperature for general microalgae species growth. In a temperate lake, Elliott et al. (2006) reported that elevated temperature contributed to the increase of phytoplankton biomass, however, nutrient loading was identified as the most prominent factor. Lake surface water temperature can be influenced by precipitation rate. Yang et al. (2021) reported that rate of precipitation was positively correlated with surface water temperature in an urban lake that drained majority impervious surfaces. However, in contrast our surface water temperature was not significantly correlated with the rate of precipitation ($R^2 = 0.14$, *P-value* = 0.47).

Total dissolved solids and electrical conductivity tolerance limits are usually not given for fish and other aquatic organisms, although they can be used as a water pollution indicator (Das et al., 2006; Pal et al., 2015). The values of our total dissolved solids and electrical conductivity measurements were typically lower than values reported in other urban tropical lakes (Sri Lanka: Weerasinghe and Handapangoda, 2019) but were very similar to those reported in Malaysia (Hossain and Mahmud, 2019).

Turbidity ranged between 29.1 and 79.3 NTU. The relationship between turbidity and chlorophyll-a concentration is complex. Decreased water clarity can limit sunlight penetration, which can result in photosynthesis limitations. Consequently, when microalgae are unable to carry out photosynthesis, chlorophyll-a concentrations can decrease (Irigoien and Castel, 1997). However, the concentration of chlorophyll-a in a lake can also impact turbidity. When the eutrophication level is high, this algal growth can contribute to increased turbidity, which can result in reduced water clarity (measured by secchi disk) (Gulati and Van Donk, 2002). It is important to understand that other factors can also influence the concentration of chlorophyll-a in water, such as nutrient availability and water temperature (Carrick et al., 1994). Therefore, while there may be a correlation between turbidity and chlorophyll-a, it is not always direct or consistent. The specific threshold for acceptable turbidity levels can vary depending on the intended use of the water body, such as drinking water, recreational activities, or aquatic biota habitat. In general, lower levels of turbidity are typically preferred as they indicate clearer and cleaner water. In Indonesia, there are no national turbidity limits for water quality, but turbidity is regulated in other

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countries, for example, Australia, Canada, and USA (Collins et al., 2011). Several published studies suggest that considering allowable increases of turbidity in clearwater systems for fish and wildlife, no more than 25 NTU above natural in streams and no more than 5 NTU above natural in lakes (Lloyd, 1987; Collins et al., 2011). However, the baseline of turbidity for lakes in Samarinda City is not available.~~Turbidity levels in Air Hitam Lake were consistently higher than these levels.~~

Anthropogenic driven nutrient enrichment of lakes has profound impacts on phytoplankton blooms. In a hypereutrophic lake in Turkey (Çelik, 2006) reported that chlorophyll-a showed significant positive correlations with phosphate concentrations during rainy seasons. Similarly, in a Swedish lake warming period, there was a concurrent increase in both phosphate and chlorophyll-a levels (Pettersson et al., 2003). Phosphate concentration in Air Hitam Lake ranged between 0.052 and 0.246 mg/L. According to Indonesia water quality monitoring regulation (PP RI No. 2/2021), concentration of 0.1 mg/L phosphate is the upper threshold to conduct aquaculture in lentic system.

Chlorophyll-a is one of the essential component in determining lake trophic status. The trophic state of aquatic ecosystems provides crucial information, as it indicates the relative health of the water body including the impact of human activity on water quality and the ecological processes of water bodies, including lakes, and reservoirs. Trophic state indices are useful in understanding phytoplankton development, which are indicated by chlorophyll-a concentration and are typically governed by the availability of nutrients and light (Carlson, 1977). Moreover, Mehner et al. (2005) reported that level of chlorophyll-a concentration is an important factor to determine fish community composition, in addition to maximum and mean depth and volume of German lakes. In tropical regions, a concentration of 10.1 µg/L and above indicates that lake or reservoir is in eutrophic state (Cunha et al., 2013). In our sampling of Air Hitam Lake, the chlorophyll-a concentration ranged between 18.6 and 116.67 µg/L indicating that it was consistently eutrophic.

Chlorophyll-a response

According to the result, chlorophyll-a in the water showed a significant negative correlation with the total precipitation ($r^2=0.71$, $p=0.035$) (Fig. 3A), meaning that total precipitation of one mm resulted in an average chlorophyll-a concentration decrease of 1.8 µg/L ~~meaning that the increase in the total precipitation resulted in a chlorophyll-a concentration decrease~~. We posit that mechanism at play here is dilution. This result is in line with the relationship between chlorophyll-a and precipitation reported by Jeong et al. (2011), who observed that summer rainfall had suppressed the high concentration of chlorophyll-a in a regulated river. However, Huang et al. (2022) reported the opposite in Chinese lakes: chlorophyll-a concentration in water was positively correlated with monthly precipitation. Positive relationships between precipitation and chlorophyll-a are assumed to be driven by the scouring effect of runoff, which transports nutrients from soils (mainly phosphorus) to lakes (Carpenter et al., 1998; Ekholm et al., 2012). In fact, mineral iron in the soil may also play an indirect effect on chlorophyll-a concentration by regulating nutrient contents such as phosphorus in the lake water (Tang et al., 2019). Interestingly, we observed that increases in total precipitation resulted in lower phosphate concentration (Fig. 2). This relationship between total precipitation and phosphate concentration helps explain why chlorophyll-a concentration responded negatively toward total precipitation (Fig. 3A) as phosphate concentration is typically positively correlated with chlorophyll-a production as seen in this study (Fig. 3C), although the regression was not significant ($r^2=0.59$,

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p=0.072). Phosphorus is sourced from both inorganic phosphates released from soil particles in lakes due to stormwater runoff and organic phosphates from untreated sewage, also influenced by precipitation. Inorganic phosphate-solubilizing bacteria play a key role by secreting organic acids like lactic acid, glycine, oxalic acid, and citric acid, which act as chelating agents, converting less soluble phosphate cations into more soluble forms (Ternan et al., 1998). Organic phosphorus undergoes a process called mineralization, facilitated by extracellular phosphatases produced by bacteria that specialize in breaking down organic phosphates (Ternan et al., 1998). These enzymes release bioavailable phosphates from organic sediments, thereby contributing to the acceleration of lake eutrophication (Zhou et al., 2008; Song et al., 2009). Tang et al. (2019) reported that intense rainfall can decrease the time water stays in a particular water body and increase water movement, which can lead to a decrease in the concentration of phosphorus in the water.

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In the area surrounding Air Hitam Lake, there are no specific activities, other than wastewater discharge, that potentially contribute to the addition of high nutrient contents in runoff (i.e. no industrial activities, urban agriculture, city slaughterhouse, etc.). Direct stormwater runoff to the lake potentially discharge larger amounts of nutrients from soils and eventually could elevate algae growth (Huang et al., 2022). Our result suggests that inflows from the inlets and direct stormwater runoff post four-day precipitation carried too little nutrients to increase the chlorophyll-a concentration in that time period. Municipal infrastructure in Samarinda City is not fully developed, and many stretches of drainage systems, for runoff and sewage, are not lined. As a result, infiltration rates are expected to be higher compared to concrete lined or piped conveyance systems. Consequently, under normal conditions, very little if any sewage discharges into Air Hitam Lake. However, during rainy periods, we observed that sewage inflows into the lake typically increased with heavy runoff. Despite increases in sewage input, we did not observe predictable, corresponding changes in measured nutrient concentrations (Fig. 2). Similar to chlorophyll-a concentrations, we suspect this was also due to dilution.

Turbidity can create a shadowing effect that can reduce photosynthesis and retard algal growth as well as chlorophyll-a concentration (Wang, 1974; Park and Kang, 2006), so we also tested the relationship between turbidity and chlorophyll-a concentration (Table 1 and Fig. 3B). Interestingly, it resulted a positive correlation between the two variables ($r=0.79$, $p=0.063$), however, the correlation was not significant. Using an identical probe, Hamdhani et al. (2021) observe similar positive trend between turbidity and chlorophyll-a concentration. Moreover, Fig. 2 shows that the accumulated rainfall had a negative trend toward turbidity, indicating that stormwater runoff carried relatively little soil (silt) particles. In this case, the precipitation runoff increased the water dilution and likely suppressing turbidity levels, similar to phosphate and chlorophyll-a concentration.

Overall, precipitation was the only significant predictor for chlorophyll-a (Table 2). The dilution from precipitation runoff likely plays an important role in Air Hitam Lake and other tropical, urban lakes, demonstrating that variations in chlorophyll-a concentration were likely affected more by dilution than by other factors. For example, the highest average of chlorophyll-a, turbidity, and phosphate levels were observed when there was zero accumulated precipitation (Figure 2). The roles of precipitation to improve water quality by diluting substance concentration in lentic systems have also been reported in other studies (Moses et al., 2011; Wu et al., 2017; Han and Bu, 2023). Finally, our findings indicate that in tropical, urban lakes, intense precipitation and resulting stormwater runoff can moderate eutrophication. This knowledge also can help managers appropriately time water quality measurements to better reflect the conditions of tropical, urban lakes.

Conclusion

In this study, the short-term relation between chlorophyll-a and the total precipitation was investigated. In the tropical urban constructed lake, we found that recent, total precipitation resulted in a significant negative correlation with the concentration of the chlorophyll-a. Our investigation indicated that although runoff increases connectivity between sewage discharge and Air Hitam Lake, the resulting nutrient loading and silt loading was relatively small. Furthermore, our findings suggest that total precipitation elevated lake water dilution, thus decreasing chlorophyll-a concentration.

Our data indicates that monitoring of chlorophyll-a in urban lakes following recent precipitation and runoff likely underestimates the normal chlorophyll-a concentration present in the system. This underestimation has implications for managers who monitor lakes for eutrophication in accordance with ecological and recreational goals and guidelines. When examining and overseeing urban, lentic ecosystems in regions with ample rainfall, it is essential to consider the impact of dilution factors. Although the trends observed in Air Hitam Lake appear to mirror those from other tropical urban lakes, additional research can help fine tune our understanding of these relationships. Additional research should examine other environmental factors under a variety of conditions such as longer-term scenarios that might encompass any delayed effects from runoff as well as different lake sizes and types of lake construction.

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Hamdhani Hamdhani
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Table 1 Water quality data from Air Hitam Lake from sampling on October 24, 2022 to December 12, 2022. Mean, maximum, and minimum values are reported.

		Date					
Parameters		24-Oct	31-Oct	7-Nov	21-Nov	5-Dec	12-Dec
pH	Mean	9.05	9.30	9.31	9.17	9.57	9.62
	Min	8.80	9.26	9.04	8.90	9.15	9.45
	Max	9.34	9.39	9.47	9.40	9.76	9.75
Dissolved Oxygen (mg/L)	Mean	4.41	5.53	10.85	10.03	11.80	13.48
	Min	3.79	4.85	8.90	9.36	9.61	11.20
	Max	5.00	6.35	12.63	11.44	13.10	16.63
Temperature (°C)	Mean	30.3	30.8	29.5	31.1	30.6	30.1
	Min	29.3	30.3	29.2	29.6	30.0	30.0
	Max	31.5	31.3	29.8	32.7	31.1	30.3
Total Dissolved Solids (ppm)	Mean	146.00	159.40	172.20	151.00	173.80	180.60
	Min	145	158	171	146	172	179
	Max	147	161	173	158	176	182
Conductivity (µS/cm)	Mean	292.20	318.80	345.00	301.80	347.80	362.00
	Min	290	317	341	291	343	359
	Max	295	322	347	315	351	365
Turbidity (NTU)	Mean	40.00	53.08	65.19	33.24	42.61	38.39
	Min	34.70	43.78	53.00	29.10	33.90	36.70
	Max	44.58	70.66	79.30	37.40	54.60	40.23
Phosphate (mg/L)	Mean	0.069	0.073	0.166	0.075	0.125	0.205
	Min	0.052	0.059	0.137	0.052	0.106	0.070
	Max	0.085	0.091	0.246	0.096	0.155	0.670
Chlorophyll-a (µg/L)	Mean	27.31	41.60	57.39	19.80	44.36	45.00
	Min	23.33	23.33	26.30	18.60	33.60	36.60
	Max	31.60	62.33	116.67	21.60	56.60	55.60
Total 4-day Precipitation (mm)		16.80	5.70	0.30	11.70	0.90	7.40

Table 2 Summary of linear regression for total 4-day precipitation (mm), turbidity (NTU), and phosphate (mg/L) predictors with chlorophyll-a concentration in Air Hitam Lake. Results include beta estimates (Estimates), confidence interval (CI), R^2, adjusted R^2, and p-value. Bold indicates significant p-values with alpha<0.05

Predictors	Estimates	CI	R^2	R^2 adjusted	p-value
(Intercept)	52.02	37.37 – 66.68	0.709	0.636	**0.001**
Precipitation	-1.79	-3.39 – -0.20			**0.035**
(Intercept)	-2.12	-48.24 – 44.00	0.621	0.526	0.905
Turbidity	0.91	-0.08 – 1.90			0.063
(Intercept)	12.57	-19.89 – 45.04	0.595	0.493	0.343
Phosphate	269.88	-39.51 – 579.27			0.073

Figure 1 Map showing Air Hitam Lake study site in Samarinda City, Indonesia with five sampling stations denotes by white stars and two inlets denoted by yellow arrows.

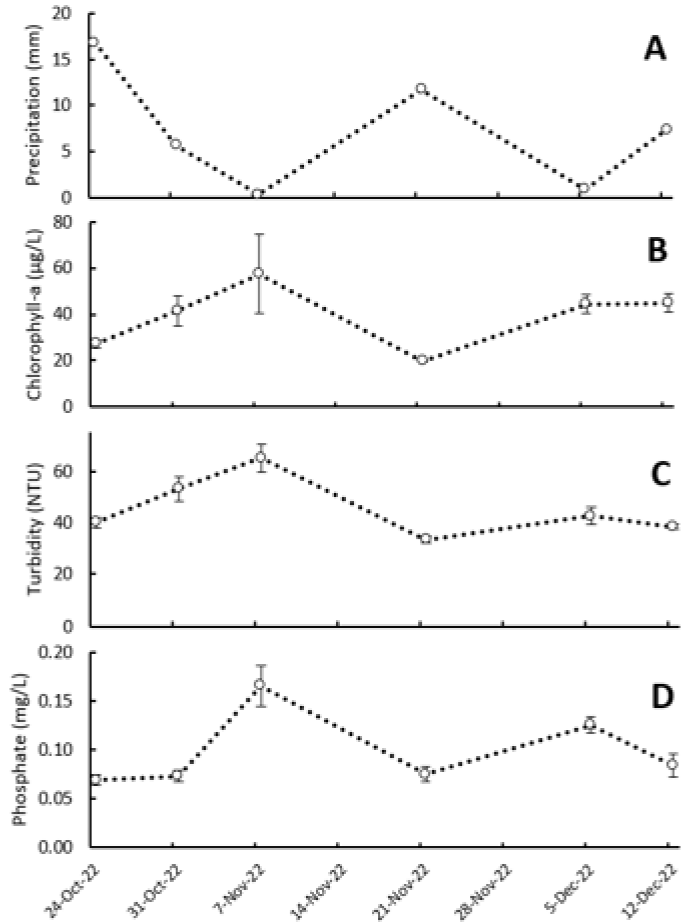

Figure 2 Plots illustrating A) 4-day total precipitation (mm) and B) average chlorophyll-a concentration (µg/L), C) turbidity (NTU), and D) phosphate concentration (mg/L) from five stations at Air Hitam Lake. Error bars indicate the Standard Error.

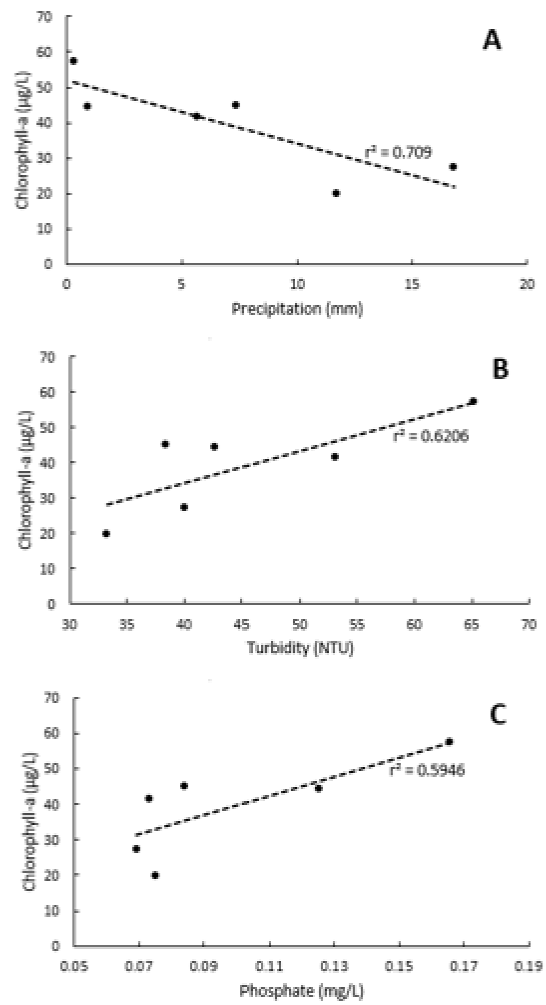

Figure 3 Scatter plots showing the relationship between Air Hitam Lake mean chlorophyll-a concentration (µg/L) with A) 4-day total precipitation (mm), B) mean turbidity (NTU), and C) mean phosphate concentration (µg/L). Dashed black line denotes the line of best fit.

c. **Respon kepada reviewer**

Reviewer(s)' Comments to Author:
Reviewer: 1

Comments to the Author
General comments

This study analyzed the relationship between chlorophyll-a and precipitation for a tropical urban lake in Indonesia. Precipitation is certainly one factor affecting lake water quality, but the connection is somewhat indirect and depends on many other factors (nutrient availability in the lake, nutrient concentration of runoff, etc.). The introduction makes the case that we don't have a good understanding of this relationship, especially for small urban lakes, but it could do a better job explaining why precipitation might lead to changes in algal biomass, and why urban lakes might respond differently to precipitation than other lakes.
H: Yes, we agree. These are the main findings and significance to our research, so it should be better supported. We have added more context and citations to justify relationship between precipitation and algal biomass and also why urban lake response might be site-specific in the Introduction section.

Moreover, the authors should provide justification for using this lake as a case study. Is it likely to be representative of many tropical urban lakes? Or is it likely that each lake would have unique relationships between precipitation and chlorophyll?
H: We have added a justification statement for using this lake as a case study (Line 134-137). We also have added clarification that this, like most research, is site specific. While the dilution effect we see in our study may hold true in other tropical urban lakes, an important covariate is nutrient additions from stormwater runoff. This will vary immensely from site to site depending on infrastructure.

The data presented here are from 6 sampling events within a 2-month period in 2022. As such, it is difficult to tease apart any general relationships for this lake from, for example, normal seasonal trends. The conclusion that timing of sampling matters seems trivial in a temporally dynamic system.
H: We have further clarified by added a citation mentioning that the tropical climate with wet and dry season characteristic is much less pronounced in Kalimantan/Borneo Island, so our October to December 2022 sampling is sufficient to represent the year-round climate condition (Line 174-178).

Specific comments:
Line 30: Is it worth listing these "basic water quality parameters"?

H: Yes, we have now listed all water quality parameters that we measured (Line 30-32).

	Lines 45-54: This connection between urban stream syndrome and urban lakes needs to be better developed. Explain how changes in hydrology and geomorphology of urban streams might affect water quality in urban lakes. Also, in many cities streams have been buried and are part of the stormwater infrastructure, which may drain directly into urban lakes. So whether or not an urban lake is fed by surficial streams may be an important factor in processing incoming nutrients. H: We agree this is an important concept as it highlights the importance of our work. So, we have added more detail regarding this connection between urban stream syndrome and urban lakes in the introduction. Line 65: Explain why runoff on impervious surfaces results in water coming into contact with human organic waste. This would probably vary across different cities, depending on wastewater infrastructure. H: More explanation has been added to clarify runoff process (Line 84-95). Lines 98-100: I like that the authors present alternative hypotheses, but these are not really competing—both could certainly be true, albeit at slightly different timescales. H: We have clarified that these predictions are for short-term responses not long-term responses. We also conducted an analyses with a longer 1 week total precipitation with chl-a and found that it was not significant. So, we will continue to use our shorter 4 day precipitation window as our metric. Line 119: No outlet—is evaporation sufficient to prevent overflow? Or is the lake designed for infiltration/groundwater recharge? H: Good question. Yes, the lake is designed for infiltrations so evaporation combined with infiltration/groundwater recharge sufficient to prevent overflow during the vast majority of rain events. Lines 148-153: The four-day rainfall window is based on hydrology (lake levels being elevated for up to four days following rain events), but it doesn't take into account temporal dynamics of phytoplankton growth. I wonder how that effects the analysis. H: It is a great question. We also ran the same regression for one-week total precipitation rather than 4 day, but the correlation with the chlorophyll-a is not significant (p-value: 0.11). There are certainly long-term dynamics at play in this and other lakes, but these were outside the scope of our study. We chose to focus on short-term responses to precipitation because of 1) this is the timeframe in which managers conduct water quality analyses and 2) there is a relative lack of published studies on short term precipitation responses in urban systems. Lines 156-158: Turbidity could affect algal growth if due to sediment inputs, for example, but phytoplankton may also account for much of the turbidity. H: Correct. We have now modified the sentence to accommodate this relationship (line 199).

Line 176: It would be good to also report DO as % saturation.
H: We agree that % saturation is a good metric. But unfortunately, we do not have this data available.

Line 221: "published"
H: Good catch. It has been corrected as suggested.

Lines 247-250: You could take this analysis one step further. How much did chlorophyll concentrations decrease on average? Does the amount of dilution (relative increase in lake water volume) fully account for this decrease?
H: Thank you for suggesting this point. Now, we have added the rate of chlorophyll-a decrease, resulted from the last four-day precipitation increase (Line 296-299). Unfortunately, we do not have discharge gages on the inflow into Air Hitam Lake, nor do we have measurements of infiltration rates, so we are unable to quantify the amount or rate of dilution occurring with stormwater runoff.

Line 254: Monthly precipitation is a very different temporal resolution, and probably is not a good comparison.
H: We certainly agree. However, we are unable to find any published studies with finer temporal resolution that can be used for comparison with our study. Accumulated monthly precipitation was the best option.

Line 260: If untreated sewage is entering the lake with stormwater runoff, that phosphorus would be primarily in organic form and would require time to mineralize and lead to increased dissolved PO4.
H: Thank you for pointing this concern. We have added more clarification statements related to phosphorus cycle (Line 314-323).

Reviewer: 2

Comments to the Author
Major suggestions:
Interesting study, some comments below.
The main finding of this study is that precipitation more than nutrients influence the variation of chlorophyll-a concentrations in Air Hitam Lake. It is likely that this phenomenon may or may not be observed in other urban water bodies. Importantly, maximum levels of nutrients can be set during periods of low rainfall. Therefore, the abstract and manuscript can be finished with a recommendation to take into account dilution effects when studying and managing aquatic ecosystems at the areas with abundant precipitation, not only further studies.

H: Yes, this is an important point that should be highlighted in our manuscript. We have included the recommendation to take into account the dilution effects in the abstract (Line 39-41) and conclusion (Line 374-375).

Table 2 demonstrates high enough correlation between chl-a and phosphate concentrations. This relationship was not statistically sufficient because of the low number of the observations as mean values from 5 sampling stations were used. But if the observations from each station would be used this relation will be statistically sufficient. Precipitation influences concentrations of both phosphate and chl-a in the same way (Table 1). Thus decrease of nutrient concentration by dilution can be a reason for phytoplankton (chl-a) decreased abundance too.
H: Our goal is to obtain an average of the lake's conditions, so from the five sampling stations, which were relatively close in proximity: approximately 200 meters away from each other. We chose to take mean values because this mirrors water quality sampling protocols used by managers.

Line 199. It can be added that in this study weak relation is observed between precipitation amounts and temperature.
H: We have added on R^2 and *P-value* for precipitation and water temperature (Line 247-248).

Minor.
Line 65. larger amounts of nutrients
H: It has been changed as suggested

Line 101. Replace "Methodology" with "Methods and materials".
H: It has been changed as suggested

Page 23, Move "Conductivity" from the line 31 to line 29.
H: It has been moved as suggested

4	Notifikasi Revisi 2	17 November 2023	**a. Email konfirmasi** **b. Laman Revisi 2 di akun jurnal**
a.	**Email konfirmasi**		

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

Lakes & Reservoirs: Science, Policy and Management for Sustainable Use - Decision on Manuscript ID LRE-23-024.R1

1 message

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Dear Dr. Hamdhani:

Manuscript ID LRE-23-024.R1 Title: "Chlorophyll-a variation in response to precipitation in a tropical urban lake"

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We recognise that the impact of the COVID-19 pandemic may affect your ability to return your revised manuscript to us within the requested timeframe. If this is the case, please let us know.

Yours sincerely,
Prof. Walter Rast
Editor-in-Chief, Lakes & Reservoirs: Science, Policy and Management for Sustainable Use

Reviewer(s)' Comments to Author:
Reviewer: 1

Comments to the Author
The manuscript has been revised in accordance with previous revision and needs minor corrections only.
Line 97 Change “fully developed nations” on “most developed countries”
Line 174 It needs a space “20cm”
Line 183 It needs a space “5:00pm”
Line 248 Change “P-value” on p

b. **Laman Revisi 2 di akun jurnal**

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Hamdhani Hamdhani

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Submission Overview

Revision 2 - Accepted

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Review Decision Letter

Article Type	Original Article
Title	Chlorophyll-a variation in response to precipitation in a tropical urban lake

Manuscript Files

Name	Type of File	Size	Last Modified
Hamdhani et al 2023-Manuscript Nov 17.docx	Main Document - MS Word	655.2 KB	Revision 2

Help

Name	Type of File	Size	Last Modified
Hamdhani et al 2023-Tracked changes-red font.docx	Main Document - Tracked Changes	649 KB	Revision 2
Reponse to reviewer 1 - Nov 17.docx	Author Response	12.1 KB	Revision 2

Abstract

With increasing urbanization, urban lakes are becoming more common and serve as important flood control infrastructure, recreational uses, as well as habitat for a variety of biota. However, given their construction, function, and location, urban lakes are susceptible to disturbances including stormwater runoff from metropolitan catchment areas. For example, nutrient loading from stormwater runoff can cause eutrophication. Chlorophyll-a concentration is an important water quality parameter because it is used to assess water quality and determine trophic state. Chlorophyll-a is known to be impacted by a number of environmental factors including precipitation and associated runoff. Previous studies indicate that the relationship between precipitation and chlorophyll-a is complex and often site-specific. In this study, we examined the relationship between chlorophyll-a and precipitation in an urban, tropical lake located in East Kalimantan Province, Indonesia. From October through December 2022, chlorophyll-a, turbidity, phosphate (PO_4), pH, dissolved oxygen, temperature, total dissolved solids, and conductivity were measured at five stations in Air Hitam Lake, and precipitation was measured adjacent to the lake. These data indicated that chlorophyll-a concentrations were negatively correlated with recent precipitation ($r^2=0.71$, $p<0.05$). This relationship was likely a result of dilution from increased lake volume. Although urban runoff is expected to increase nutrient loading, our monitoring indicated that dilution can mediate this process in the short-term. Our findings suggest that timing matters when monitoring water quality in tropical, urban lakes. Sampling immediately following heavy precipitation and stormwater runoff can lead to an underestimation of normal chlorophyll-a concentrations due to dilution. As a result, dilution effects should be examined when studying and managing urban lentic ecosystems with strong precipitation dynamics. Further studies are necessary to better

understand these urban aquatic ecosystems to continue to improve future management efforts.

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Additional Information

Is your data available?

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Funders

No funding was received for this manuscript

Keywords

water pollution; lentic; Samarinda; Kalimantan; Borneo

Is this submission for a special issue?

No, this is not for a special issue

History

Accepted On 22 December 2023 by Editorial Office

5	Hasil Revisi 2	17 November 2023	**Respon kepada reviewer**

Respon kepada reviewer

Reviewer(s)' Comments to Author:
Reviewer: 1

Comments to the Author
The manuscript has been revised in accordance with previous revision and needs minor corrections only.

Line 97 Change "fully developed nations" on "most developed countries"
H: It has been changed as suggested (line 94)

Line 174 It needs a space "20cm"
H: A space was added (line 172)

Line 183 It needs a space "5:00pm"
H: A space was added (line 180)

Line 248 Change "P-value" on p
H: Good catch. It has been corrected as suggested (line 248)

6	Konfirmasi final – artikel diterima	22 Desember 2023	**1) Email konfirmasi** **2) Laman notifkasi akun jurnal**

a. Email konfirmasi

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

Lakes & Reservoirs: Science, Policy and Management for Sustainable Use - Decision on Manuscript ID LRE-23-024.R2

3 messages

LRE EO Temp <onbehalfof@manuscriptcentral.com> Fri, Dec 22, 2023 at 10:55 AM
Reply-To: lre.eo@wiley.com
To: hamdhani@fpik.unmul.ac.id, musyiir02@gmail.com, deppehimer@arizona.edu, samsulrizal@fpik.unmul.ac.id
Cc: lakes@wiley.com

21-Dec-2023

Dear Dr. Hamdhani:

Manuscript number: LRE-23-024.R2
Title: Chlorophyll-a variation in response to precipitation in a tropical urban lake

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We hope you will consider submitting future manuscripts on your work to Lakes and Reservoirs: Research and Management.

Yours sincerely,

Prof. Walter Rast (Editor-in-Chief)
Lakes & Reservoirs: Science, Policy and Management for Sustainable Use

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Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author
The ms has revised with an accordance of previous revision. I believe that it can be publish in the Lakes & Reservoirs: Science, Policy and Management for Sustainable Use.

Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id> Fri, Dec 22, 2023 at 12:17 PM
To: Drew Eppehimer <deppehimer@gmail.com>

Hi Drew,
Finally accepted in a Wiley Journal ;-)
Thank you so much for your help in making the manuscript ready.
[Quoted text hidden]

Drew Eppehimer <deppehimer@gmail.com> Fri, Dec 22, 2023 at 12:26 PM
To: Hamdhani Hamdhani <hamdhani@fpik.unmul.ac.id>

WOOOHOOOOO!!!!!!

Nice work, Hamdhani!
[Quoted text hidden]

b. Laman notifkasi akun jurnal

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Decision letter (Revision 2)

Chlorophyll-a variation in response to precipitation in a tropical urban lake

Subject Lakes & Reservoirs: Science, Policy and Management for Sustainable Use - Decision on Manuscript ID LRE-23-024.R2

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