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Research Article

Urban Lakes, South Tangerang City Based on Water Quality Index and Phytoplankton Composition as Bioindicator

Yayan Mardiansyah Assuyuti[1], Ahmad Zulfikar Wicaksono[1], Dasumiati Dasumiati[1], Khohirul Hidayah[1], Firdaus Ramadhan[2], Alfan Farhan Rijaluddin[3], Dinda Rama Haribowo[4]

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ORCID IDs of the author:
Y.M.A. 0000-0002-3254-5414;
A.Z.W. 0000-0001-9059-257X;
D.D. 0000-0001-5143-3998;
K.H. 0000-0003-0849-9435;
F.R. 0000-0002-8050-1205;
A.F.R.0000-0003-2749-1375;
D.R.H. 0000-0002-2896-0850

[1]Department of Biology, Faculty of Science and Technology, Syarif Hidayatullah State Islamic University (UIN), South Tangerang, Banten, Indonesia

[2]Laboratory of Microbiology, Faculty of Pharmacy, National Institute of Science and Technology (ISTN), South Jakarta, Indonesia

[3]Laboratory of Environment, PT. Unilab Perdana, South Jakarta, Indonesia

[4]Laboratory of Ecology, Center for Integrated Laboratory, Syarif Hidayatullah State Islamic University (UIN), South Tangerang, Banten, Indonesia

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Correspondence:
Dinda Rama Haribowo
E-mail:
dindarama.haribowo@uinjkt.ac.id

ABSTRACT

An assessment of water quality in 8 urban lakes in South Tangerang City was conducted, as their condition was a concern. This research aims to assess water quality based on the condition of chemical-physical variables and phytoplankton composition. This research was conducted from late May to early October 2021 (the dry season until the inter-seasonal period). The Water Quality Index (WQI) ranged from 61.18-79.53 (medium-good). Phytoplankton composition consisted of 65 genera from 11 classes and 6 divisions. Oscillatoria, Euglena and Pediastrum were the dominant genera, meanwhile, Cyanophyceae and Chlorophyceae were the dominant class. Phytoplankton communities in all lakes were stable except RL and based on Jaccard index the value of inter-lakes show no identical similarities (≠ 1). In (Nygaard) values ranged from 2.50-undefined (slight-high eutrophication), and X (Saprobic indices) values ranged from 0.33-1.80 (very slight pollution-moderate pollution). The best correlations (both values were r = 0.53) in water quality between the variables were DO (ppm) and BOD (ppm) Urban lakes require further improvement in their lake management to be used as sources of drinking water.

Keywords: Water quality variables, Phytoplankton, Urban lakes

INTRODUCTION

The South Tangerang City lakes are located in urban areas with a high human population density and a high level of public interface (Birch & McCaskie, 1999); therefore, South Tangerang City lakes are classified as urban lakes. An urban lake is susceptible to water quality deterioration (Birch & McCaskie, 1999; Norris & Laws, 2017). There are 8 urban lakes in South Tangerang City, Banten with concerning conditions (Regional Regulation of South Tangerang City Number 9, 2019). Information indicating the deterioration of their water quality is available (Fauzi, 2016).

Water quality deterioration in South Tangerang City lakes occurred because of domestic sewage flow and recreational and aquaculture activities therein, which led to an increase in water pollution and eutrophication with a potential phytoplankton bloom (Vardaka et al., 2000; Katsiapi et al., 2013; Wang et al., 2013). Phytoplankton bloom can be harmful to the aquatic ecosystem. Moreover, it can be harmful to humans and can cause illness and death when ingested or when humans are exposed to it (Vardaka et al., 2000; Norris & Laws, 2017). On the other hand, the local government had been designing lake management for South Tangerang City lakes as source waters for drinking water (Regional Regulation of South Tangerang City Number 9 of 2019, 2019). Before using the lakes for drinking water and other daily activities, it is important to conduct an assessment of water quality (Bhateria & Jain, 2016).

The Water Quality Index (WQI) method based on Pesce & Wunderlin (2000) and Kannel et al.'s

(2007) research has been generally known as one of the most important indices for water quality assessment (Bhateria & Jain, 2016; Dunca, 2018). Although it is a good indicator of water quality, if applied with no biological variable, the result will be insufficient and it will lack ecological factors (Bordoloi & Baruah, 2014; Yusuf, 2020). It requires a biological variable analysis based on a phytoplankton analysis. Phytoplankton is tolerant, it rapidly responds to the alteration of its environmental condition and it possesses a short life cycle (Bellinger & Sigee, 2010; Maznah & Makhlough, 2014). It is important to assess phytoplankton indices and their composition in urban lakes. The high human population density in urban lakes is closely related to water pollution, which leads to eutrophication (Kalaji et al., 2016). Nutrient loading from anthropogenic activities and increasing temperatures induce eutrophication and may favor the predominance of harmful phytoplankton (de Souza et al., 2018).

Phytoplankton indices such as saprobic and Nygaard have been widely applied for pollution and eutrophic assessments in lakes (Jafari & Gunale, 2006; Maznah & Makhlough, 2014; Prasetyaningsih & Sahidin, 2019; Toma, 2019). The saprobic index was applied for a pollution level assessment. The Nygaard index was applied for a trophic level assessment (Nygaard, 1949; Dresscher & Mark, 1976). Dominant phytoplankton genus and class assessments were also applied widely to assess pollution and eutrophication in lakes (Wang et al., 2013; Zhu et al., 2021). Thus, phytoplankton has been a good bioindicator for water quality assessment.

Eutrophication and phytoplankton bloom information was not acquired in previous research (Bahri et al., 2015; Assuyuti et al., 2019; Zharifa et al., 2019) although, it is good to perform water quality assessment before using lakes as drinking water or recreational areas (Vardaka et al., 2000; Wang et al., 2013; Norris & Laws, 2017). Therefore, an assessment water quality of 8 urban lakes in South Tangerang City is required for lake management information. This research aims to assess the water quality of the 8 urban lakes in South Tangerang City based on chemical-physical variables analysis, the Water Quality Index (WQI) and phytoplankton analyses.

MATERIALS AND METHODS

Site study and sampling

The research was conducted in 8 urban lakes in South Tangerang City, Banten, Indonesia from late May to early October 2021, representing the dry season until the inter-seasonal period. The Urban lakes in South Tangerang City were Pondok Jagung Lake (PJL), Parigi Lake (PARL), Rompong Lake (RL), Bungur Lake (BL), Gintung Lake (GL), Kuru Lake (KL), Ciledug Lake (CL) and Pamulang Lake (PAML). Local people use the lake in South Tangerang City for household waste disposal, tourism and fishing. There were 5 sampling points for each lake, which were determined based on their inlet, outlet and utilizations area, such as aquacultures and recreational activities (Figure 1).

Phytoplankton sampling was carried out by plankton net (50 µm mesh size) in the euphotic zone (0-50 cm) of each lake. Phytoplankton samples were preserved using Lugol 10% drop by drop until they changed color to a yellowish-brown or a dark brown. They were then stored in a refrigerator (Suthers and Rissik, 2009). Surface water from each lake was collected for Biological Oxygen Demand (BOD), PO_4-P and NO_3-N analyses in the Laboratory of Ecology, Center of Integrated Laboratory, Syarif Hidayatullah State Islamic University.

Water variables and phytoplankton identification

Electrical Conductivity (EC), Total Dissolved Solids (TDS), pH and Water Temperature (W_{temp}) were measured using a Hanna multi-parameter instrument (HI 9811). Dissolved Oxygen (DO) was measured using a Lutron DO meter (DO-5510) and Turbidity (TUR) was measured using a Hanna Turbidity meter (HI 9373). Water transparency based on Secchi Disk Depth (SDD) was measured as described in (Adhar et al., 2021). PO_4-P, NO_3-N and Biological Oxygen Demand (BOD) analyses were conducted based on standard methods described in EPA (1983) and APHA (2017). Phytoplankton identification was assisted by an Olympus light binocular microscope and Sedgwick-Rafter Cell (SRC) as counting chamber. Phytoplankton was identified based on Karacaoğlu et al., (2004), van Vuuren et al., (2006), Bellinger & Sigee (2010) and Sulastri (2018). The naming of taxa was based on currently accepted nomenclature (Guiry & Guiry, 2021).

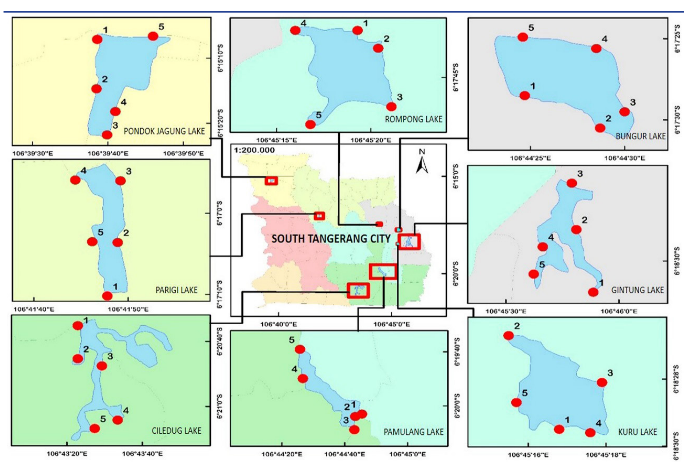

Figure 1. Map of 8 urban lakes in South Tangerang City and their sampling point locations.

Data analysis

Chemical-physical variables measurement results were analyzed using Water Quality Index (WQI) with the following categories: very bad (0–25), bad (26–50), medium (51–70), good (71–90), and excellent (90–100) (Kannel et al., 2007). Phytoplankton genera were counted and analyzed based on a formulation described in APHA (2017). Phytoplankton genus and class domination were analyzed using relative abundance calculation based on Kumar & Mina (2021). The phytoplankton community was analyzed using the Shannon-Wiener diversity index (H'), Pielou evenness index (J') and Simpson dominance index (D) based on the formulation as described in Dash & Dash (2009). Clustering analysis was conducted based on the UPGMA (Unweighted Pair

Group Method with Arithmetic Mean) method, which is suitable for describing the relationship inter-lakes based on phytoplankton similarity (Carteron et al., 2012). Jaccard similarity index measurement and phytoplankton similarity clustering inter-lakes were assisted by PAST 4.03. Trophic and pollution degree were assessed by Nygaard (In) and saprobic indices (X) based on the formulation as described in Nygaard (1949) and Dresscher & Mark (1976).

Statistical analysis

A non-parametric Kruskal-Wallis H test (One-way ANOVA on ranks) was used to determine statistically significant differences in chemical-physical measurement results, WQI results and phytoplankton abundances between lakes. Non-parametric Spearman's correlation was used to correlate chemical-physical variables measurement result and phytoplankton abundance toward water quality index result. Spearman's correlation coefficient describes the correlation's strength and direction. The strength and direction of correlation between research variables refer to Verla et al. (2020). Statistical analyses were assisted by IBM SPSS 20.

RESULTS AND DISCUSSION

Water Variables

Physical variables measurement results in the lakes ranged from 28.7-32.4°C (Wtemp), 82-236 ppm (TDS), 140-488 µs·cm^{-1} (EC), 24.6-50.2 cm (SDD) and 29.7-75.4 FTU (TUR). Meanwhile, chemical variables measurement results in the lakes ranged from 7.3-9.6 (pH), 4-7.5 ppm (DO), 1.3-24.1 ppm (BOD), 0.01-0.4 ppm (PO_4-P), 0.1-7.6 ppm (NO_3-N) (Table 1). Based on the non-parametric Kruskal-Wallis H test for chemical-physical variables measurement, results between lakes indicated a significant difference ($p<0.05$) unless the SDD value indicated no significant difference between lakes ($p>0.05$). Chemical-physical variables conditions in the lakes were out of the range of water quality standards for drinking water (Government Regulation of Republic Indonesia Number 22 of 2021, 2021; World Health Organization, 2017).

Chemical-physical variables conditions in the lakes were outside of the range from water quality standards for drinking water, except for TDS and EC (Table 1). W_{temp} in the lakes ranged within the optimum range for the metabolic processes of aquatic organisms, i.e., 20-35°C (Piranti et al., 2021a). TDS and EC conditions in the lakes ranged within water quality standards for drinking water, however, their results in GL were excessively higher than other lakes. High values of TDS and EC indicate high levels of dissolved ions as a result of household wastewater and leachate from municipal solid waste discharge into the lake (Pujiindiyati et al., 2019; Sulastri et al., 2019).

SDD and TUR values are closely related to light penetration in lakes, which affected phytoplankton growth (Sobolev et al., 2009; Zhou et al., 2019). TUR results in the lakes exceeded the optimum value for phytoplankton growth, i.e., 15 FTU (Sobolev et al., 2009). pH result in BL was solely out of the range from water quality standards for drinking waters, i.e., 9.6. However, a high pH value in the lake indicates a productive lake with a high intensity of photosynthesis (Sulawesty & Aisyah, 2020).

DO levels in PARL and RL were out of the range of water quality standards for drinking water. Mainly, the DO level in RL was much lower than other lakes in South Tangerang City, i.e., 4 ppm. A low level of DO in RL was the indication of water hyacinth bloom, as water hyacinth bloom shades the water column of the lake and limits light intensity for photosynthesis (Mironga et al., 2012). BOD level in PJL was solely within water quality standards for drinking water, i.e., 1.3 ppm. Different results for BOD in BL were obtained where the value was outside of water quality standards for drinking water with a value of 24.1 ppm. BOD level was a good indicator of water pollution (Dhanam et al., 2016; Mohamed et al., 2017). As a productive lake, BL was a lake with the highest BOD level. It occurred as the increase of phytoplankton photosynthesis and growth rate parallel to phytoplankton death, which led to the increase of oxygen consumption for aerobic microorganisms' decomposition (Sulawesty & Aisyah, 2020).

NO_3-N and PO_4-P are required for phytoplankton growth, but their presence in lakes might produce phytoplankton bloom, which deteriorated water quality (Mohamed et al., 2017; Wijaya & Elfiansyah, 2022). PO_4-P levels in PJL, PARL and KL ranged within water quality standards for drinking water, otherwise,

Table 1. Chemical-physical variables conditions in 8 urban lakes in South Tangerang City

Variables	PJL	PARL	RL	BL	GL	KL	CL	PAML	QS^{A,B}
Wtemp (°C)	30.9±1	29.4±0.6	29.5±1.4	32.4±0.4	29.4±1	28.7±0.5	30.7±0.5	31.5±1.4	25^{B}
TDS (ppm)	62±11.7	98±7.5	164±18.5	72±9.8	236±33.8	82±7.5	138±47.9	126±25.8	1000^{A}
EC (µs·cm^{-1})	140±26.1	218±9.8	354±39.3	160±15.5	488±69.4	186±17.4	308±110.3	290±83.7	1200^{B}
SDD (cm)	28±10.3	50.2±11.9	32.6±20	27.9±12.2	24.6±5.7	38.3±13	46.8±13.2	35.1±16.1	1000^{A*}
TUR (FTU)	57.7±6	29.7±7.9	36.7±17.2	75.4±2.6	29.7±16.8	66.8±7.7	31.9±11.2	40.1±23.5	1^{B}
pH	8.3±0.7	7.3±0.1	7.3±0.2	9.6±0.3	7.8±0.1	8±0.5	7.7±0.6	7.9±0.6	6-9^{A}
DO (ppm)	6.7±0.6	5.9±0.7	4±0.6	7±1.1	6.8±2	7.3±1.3	6.6±1.8	7.5±1.2	6^{A*}
BOD (ppm)	1.3±0.7	9.2±5.5	6.1±5.3	24.1±7.3	6.5±1.8	6.4±2.3	12.6±6.2	8.2±3	2^{A}
PO_4-P (ppm)	0.01±0.01	0.01±0.01	0.02±0.01	0.02±0.01	0.1±0.1	0.01±0.01	0.4±0.5	0.1±0.1	0.01^{A}
NO_3-N (ppm)	0.2±0.1	3.1±3.9	1.4±1.5	1.9±1.5	0.2±0.1	7.6±14.2	0.2±0.1	0.1±0.04	0.65^{A}

Note: A = Water quality standards based on Government Regulation of Republic Indonesia Number 22 of 2021, 2021; B = Water quality standards based on World Health Organization, 2017; * = Minimum quality standards limit.

PO_4-P levels in GL, CL and PAML ranged within optimum PO_4-P levels for phytoplankton growth (0.09-1.8 ppm) (Yuliana & Irfan, 2018). NO_3-N level in PJL ranged within water quality standards for drinking waters along with GL, CL and PAML. PARL, RL, BL and KL ranged within the optimum range for phytoplankton growth (0.9-3.5 ppm) except the NO_3-N level in KL (Yuliana & Irfan, 2018).

Water quality index

Water Quality Index (WQI) measurement results in the lakes ranged from 61.18-79.53. PJL, GL, KL and PAML lakes had values >71 within the good category otherwise. Furthermore, PARL, RL, BL and CL had values >51 within the medium category (Table 2).

Table 2. WQI results in 8 urban lakes in South Tangerang City.

Lakes	Average WQI	Category
PJL	79.53±1.95	Good
PARL	68.82±5.35	Medium
RL	67.41±6.89	Medium
BL	61.18±5.53	Medium
GL	72.71±5.71	Good
KL	72.94±8.71	Good
CL	66.82±7.95	Medium
PAML	72.71±6.30	Good

The results of the non-parametric Kruskal-Wallis H test between lakes for WQI results indicated a significant difference ($p<0.05$). WQI values variation in the lakes occurred as a result of various situations in each lake location and waste discharge into the lakes (Kannel et al., 2007; Assuyuti et al., 2019). The previously reported average WQI values in GL were >74 in each period (before, on and after Ramadan) (Assuyuti et al., 2019).

WQI results in PJL were categorized as good with low levels of PO_4-P and NO_3-N, indistinct from other lakes, which had higher levels of PO_4-P and NO_3-N. Increasing levels of PO_4-P and NO_3-N are associated with household waste discharge from the community surrounding the lakes (Patil et al., 2012; Mohamed et al., 2017; Naqqiuddin et al., 2017). Household waste pollution in RL, BL and CL induced them to have a moderate category based on WQI. GL, KL and PAML were contaminated based on PO_4-P and NO_3-N levels but were categorized in the good category based on WQI. It occurred because GL, KL and PAML had high DO levels, while their BOD levels were low. According to Kannel et al. (2007) and Bhateria & Jain (2016), DO and BOD levels are important parameters for aquatic organisms and ecosystems.

Composition of phytoplankton

There were 65 phytoplankton genera from 11 classes and 6 divisions observed in the lakes. The dominant phytoplankton genus in PJL, PARL, RL, BL, GL and PAML was *Oscillatoria* spp. Meanwhile,

Table 3. Phytoplankton genera's relative abundance in 8 urban lakes in South Tangerang City.

Phytoplankton	Relative abundance percentages							
	PJL	PARL	RL	BL	GL	KL	CL	PAML
Achnanthes spp. Bory, 1822	0%	0%	0%	0%	0%	0%	0%	0%
Actinastrum spp. Lagerheim, 1882	0%	0%	0%	0%	0%	0%	0%	0%
Amphipleura spp. Kützing, 1844	0%	0%	0%	0%	0%	0%	0%	0%
Anabaena spp. Bory ex Bornet & Flahault, 1886	0%	0%	0%	0%	0%	0%	0%	0%
Ankistrodesmus spp. Corda, 1838	0%	0%	0%	0%	1%	0%	0%	0%
Aphanizomenon spp. Morren ex Bornet & Flahault, 1888	0%	0%	0%	0%	0%	0%	0%	0%
Arthrospira spp. Sitzenberger ex Gomont,1892	0%	13%	0%	0%	3%	0%	0%	6%
Aulacoseira spp. Thwaites, 1848	1%	2%	1%	0%	6%	0%	0%	0%
Chlamydomonas spp. Ehrenberg,1833	0%	0%	0%	0%	0%	0%	1%	1%
Chlorella spp. Beijerinck, 1890	0%	0%	0%	0%	0%	0%	2%	1%
Chroococcus spp. Nägeli, 1849	0%	0%	0%	0%	0%	0%	0%	0%
Cladophora spp. Kützing, 1843	0%	0%	0%	0%	0%	0%	0%	0%
Closterium spp. Nitzsch ex Ralfs, 1848	0%	0%	28%	0%	0%	0%	0%	0%
Coelastrum spp. Nägeli, 1849	0%	0%	0%	0%	0%	1%	1%	0%
Coelosphaerium spp. Nägeli, 1849	0%	0%	0%	5%	1%	0%	1%	0%
Cosmarium spp. Corda ex Ralfs, 1848	0%	0%	0%	0%	0%	0%	0%	0%
Cyclotella spp. (Kützing) Brébisson, 1838	2%	8%	0%	1%	2%	7%	0%	0%
Cylindrospermopsis spp. Seenayya & Subba Raju, 1972	0%	0%	0%	0%	1%	0%	0%	0%
Cymbella spp. Agardh, 1830	0%	0%	0%	0%	0%	0%	0%	0%
Desmidium spp. Agardh ex Ralfs, 1848	0%	0%	0%	0%	0%	0%	0%	0%
Dictyosphaerium spp. Nägeli, 1849	0%	0%	0%	0%	2%	0%	2%	0%
Eudorina spp. Ehrenberg, 1832	0%	1%	0%	0%	0%	0%	3%	0%
Euglena spp. Ehrenberg, 1830	1%	2%	5%	1%	8%	**25%**	23%	5%
Fragilaria spp. Lyngbye, 1819	0%	8%	0%	2%	0%	0%	0%	0%

Table 3. Continue.

Phytoplankton	Relative abundance percentages							
	PJL	PARL	RL	BL	GL	KL	CL	PAML
Gleocapsa spp. Kützing, 1843	0%	1%	0%	0%	0%	0%	0%	0%
Gomphonema spp. Ehrenberg, 1832	0%	0%	0%	0%	0%	0%	0%	0%
Gomphosphaeria spp. Kützing, 1836	0%	0%	0%	0%	0%	0%	0%	0%
Gonium spp. Müller, 1773	0%	0%	0%	0%	0%	0%	0%	1%
Gyrosigma spp. Hassall, 1845	0%	0%	0%	0%	0%	0%	0%	0%
Haematococcus spp. Flotow, 1844	0%	0%	0%	0%	1%	0%	1%	1%
Kirchneriella spp. Schmidle, 1893	0%	0%	0%	0%	0%	0%	0%	0%
Lyngbya spp. Agardh ex Gomont, 1892	0%	3%	3%	0%	0%	15%	0%	0%
Mallomonas sp. Perty, 1852	0%	0%	0%	0%	0%	0%	0%	0%
Melosira spp. Agardh, 1824	2%	0%	0%	0%	0%	0%	0%	0%
Merismopedia spp. Meyen, 1839	0%	0%	0%	20%	0%	0%	0%	1%
Micrasterias spp. Agardh ex Ralfs, 1848	0%	0%	0%	0%	0%	0%	0%	0%
Microcystis spp. Lemmermann, 1907	2%	0%	3%	15%	1%	3%	3%	1%
Navicula spp. Bory, 1822	5%	0%	1%	1%	0%	5%	1%	1%
Nitzschia spp. Hassall, 1845	0%	0%	0%	0%	0%	4%	6%	0%
Oocystis spp. Nägeli ex Braun, 1855	7%	1%	0%	6%	1%	1%	1%	1%
Oscillatoria spp. Vaucher ex Gomont, 1892	**63%**	**47%**	**42%**	**34%**	**43%**	23%	15%	**25%**
Pandorina spp. Bory, 1826	0%	0%	0%	0%	0%	0%	3%	12%
Pediastrum spp. Meyen, 1829	0%	9%	0%	2%	0%	0%	**28%**	16%
Penium spp. Brébisson ex Ralfs, 1848	5%	1%	0%	0%	0%	0%	0%	0%
Phacus spp. Dujardin, 1841	1%	2%	13%	7%	21%	8%	5%	19%
Phormidium spp. Kützing ex Gomont, 1892	0%	0%	0%	0%	0%	1%	0%	0%
Pinnularia spp. Ehrenberg, 1843	0%	0%	0%	0%	0%	0%	0%	0%
Pleurotaenium spp. Nägeli, 1849	3%	0%	0%	0%	0%	0%	0%	0%
Pseudaanabaena spp. Lauterborn, 1915	7%	0%	1%	0%	5%	0%	0%	0%
Quadrigula spp. Printz, 1916	0%	0%	0%	0%	0%	0%	0%	0%
Scenedesmus spp. Meyen, 1829	0%	0%	0%	5%	0%	1%	1%	2%
Selenastrum spp. Reinsch,1866	0%	0%	0%	0%	0%	0%	0%	0%
Sphaerocystis spp. Chodat, 1897	0%	0%	0%	1%	0%	0%	2%	3%
Spirogyra spp. Link, 1820	0%	0%	1%	0%	0%	0%	0%	0%
Stephanodiscus spp. Ehrenberg, 1845	0%	0%	0%	0%	0%	0%	0%	0%
Strombomonas spp. Deflandre, 1930	0%	0%	0%	0%	0%	0%	1%	0%
Surirella spp. Turpin, 1828	0%	0%	0%	0%	0%	0%	0%	0%
Synechococcus spp. Nägeli, 1849	0%	0%	0%	0%	0%	1%	0%	0%
Synedra spp. Ehrenberg, 1830	0%	1%	0%	0%	0%	1%	0%	0%
Tetraëdron spp. Kützing, 1845	0%	0%	0%	0%	0%	0%	0%	0%
Tetrastrum spp. Chodat, 1895	0%	0%	0%	0%	0%	0%	0%	0%
Trachelomonas spp. Ehrenberg, 1834	0%	0%	0%	0%	0%	0%	0%	0%
Tribonema spp. Derbès & Solier, 1851	0%	0%	0%	0%	0%	0%	0%	0%
Ulothrix spp. Kützing, 1833	0%	1%	0%	0%	0%	0%	0%	0%
Volvox spp. Linnaeus, 1758	0%	0%	0%	0%	0%	0%	0%	0%

Note: bold = Dominant genus in each lake (phytoplankton genus with the highest relative abundance)

the dominant phytoplankton genera in KL and CL were *Euglena* spp. and *Pediastrum* spp. respectively (Table 3). The abundance percentage of phytoplankton classes in PJL, PARL, RL, BL, GL and KL were dominated by Cyanophyceae (72%, 64%, 49%, 74%, 54% and 44%). Meanwhile, the abundance percentage in CL and PAML was dominated by Chlorophyceae (39% and 38%). Bacillariophyceae, Coscinodiscophyceae, Mediophyceae, Trebouxiophyceae and Ulvophyceae classes had low abundance percentages in each lake (<10%) (Table 4). Total phytoplankton abundance values in the lakes ranged from 175-3224 ind·L^{-1}. RL is the highest (3224 Ind·L^{-1}) and PJL is the lowest (175 Ind·L^{-1}) (Table 5). The non-parametric Kruskal–Wallis H test indicated a significant difference in phyto-

Table 4. Phytoplankton classes' relative abundance percentage in 8 urban lakes in South Tangerang City.

Classes	Lakes							
	PJL	PARL	RL	BL	GL	KL	CL	PAML
	Relative abundance percentages							
Bacillariophyceae	5%	9%	1%	2%	0%	10%	7%	1%
Chlorophyceae	0%	11%	1%	8%	5%	2%	39%	38%
Coscinodiscophyceae	3%	2%	1%	0%	6%	0%	0%	0%
Cyanophyceae	72%	64%	49%	74%	54%	44%	21%	34%
Euglenophyceae	2%	4%	18%	7%	28%	34%	29%	24%
Mediophyceae	2%	8%	0%	1%	2%	7%	0%	0%
Chrysophyceae	0%	0%	0%	0%	0%	0%	0%	0%
Trebouxiophyceae	8%	1%	0%	6%	3%	1%	5%	3%
Ulvophyceae	0%	1%	0%	0%	1%	0%	0%	0%
Xanthophyceae	0%	0%	0%	0%	0%	0%	0%	0%
Zygnematophyceae	8%	1%	30%	0%	0%	1%	0%	0%

Table 5. Total phytoplankton abundance (Indv/L^{-1}) values in 8 urban lakes in South Tangerang City.

Lakes	Total Abundances Phytoplankton
PJL	175
PARL	700
RL	3224
BL	496
GL	805
KL	671
CL	878
PAML	1147

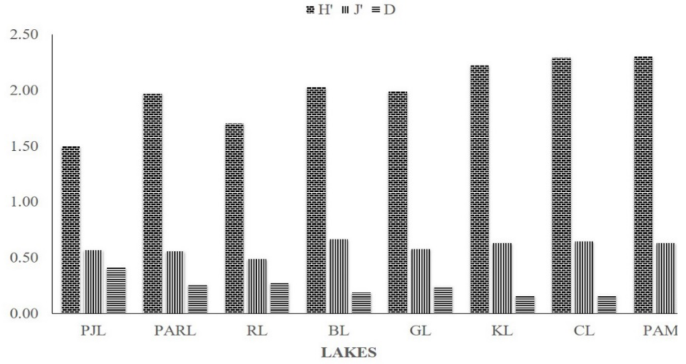

Figure 2. Diversity (H'), evenness (J') and dominance (D) indices' values in 8 urban lakes in South Tangerang City.

plankton abundances between lakes ($p<0.05$). H' values in the lakes ranged from 1.50-2.30. J' values in the lakes ranged from 0.49-0.67. D values ranged from 0.19 to 0.41.

Oscillatoria, *Euglena* and *Pediastrum* were found to be the dominant genera in the lakes. The results indicated that they were polluted and underwent eutrophication. According to Kshirsagar (2013), *Oscillatoria*, *Euglena* and *Pediastrum* are genera of phytoplankton used for pollution indicators. Furthermore, *Oscillatoria* was abundant in each lake, reinforcing pollution indications which occurred in the lakes. It was also reported by previous research in Ousteri Lake, India and Segara Anakan, Indonesia that *Oscillatoria* spp. was dominant as it is the highly tolerant genus to polluted waters (Dhanam et al., 2016; Piranti et al., 2021b). Relative abundance of phytoplankton genera might change rapidly as their physiological mechanisms for growth and loss respond to the alteration of chemical-physical variables condition (Kagami et al., 2002; Bellinger & Sigee, 2010; Utomo et al., 2013).

Increasing organic pollution and eutrophication led domination of Cyanophyceae and Chlorophyceae. This is reinforced by the domination of high pollution-tolerant genera from them, i.e., *Oscillatoria*, *Pediastrum* and *Pandorina* (Jafari & Gunale, 2006; Kshirsagar, 2013). Domination of Cyanophyceae and Chlorophyceae also occurred previously in Baiyangdian Lake, China due to increasing organic pollution (Wang et al., 2013). PJL had slight organic pollution based on the BOD level, followed by low levels of PO_4-P and NO_3-N. The limited content of NO_3-N on the PJL surface waters is thought to have caused the Cyanophyceae class, mainly *Oscillatoria*, to become dominant which is a nitrogen-fixing genus and can generate gas vacuoles to remain in the water surface of the lake (Padmavathi & Prasad, 2007).

Cyanophyceae class domination caused blooming to form as a green surface scum or foam on the surface of the lake, which interfered with light intensity to a water column of the lake (Howard, 1994; van Vuuren et al., 2006). Low light intensity and toxin secretion from several genera of Cyanophyceae established low abundance percentages for Trebouxiophyceae and Ulvophyceae, as they are limiting factors for phytoplankton photosynthesis (Bellinger & Sigee, 2010; Liang et al., 2015). Based on previous research, diatom taxa (Bacillariophyceae, Coscinodiscophyceae and Mediophyceae) were unable to adapt to the limited phosphorus competition with Cyanophyceae class (Amano et al., 2010).

Total phytoplankton abundance in RL was higher than other lakes in South Tangerang City because of invasive aquatic plants overgrown, i.e., water hyacinth. The adsorption function of root trap in water hyacinth increased phytoplankton abundance surrounding it (Wang & Yan, 2017). Mainly, it increased phytoplankton abundance of tolerant genera in high-pollutant lakes such as *Oscillatoria* and *Closterium*, which were observed abundant in RL (Table 3). A high density of water hyacinth also inhibits the growth of submerged aquatic plants, which play an important role in controlling the phytoplankton population (Mironga et al., 2012; Zeng et al., 2017; da Silva et al., 2018).

PJL was the lowest total phytoplankton abundance in the lakes, followed by BL, as BL was the lowest total phytoplankton abundance in the lakes behind PJL (<500 Ind·L^{-1}). The total abundance of phytoplankton decreased allegedly because the sediments in PJL and BL were dredged. The previous research also reported a decrease in phytoplankton biomass after sediment dredging occurred (Norris & Laws, 2017). Total phytoplankton abundances in PJL and BL were decreased, but Cyanophyceae constantly dominated in them. Presumably, sediment dredging merely reduces phytoplankton biomass and nutrient loading without controlling Cyanophyceae's population.

H' values in PJL, PARL, RL and GL indicated heavy pollution (1<H'<2), meanwhile H' values in BL, CL, KL and PAML indicated moderate pollution (2<H'<3) (Gao et al., 2018). The lakes in South Tangerang City had undergone moderate-heavy pollution, however, there was no dominant phytoplankton genus within phytoplankton communities in the lakes as D values in the lakes were low and phytoplankton communities were stable (D<0.5) (Nurfadillah et al., 2022). The D values were supported by J' values in the lakes, except RL, which was high with even dispersion of phytoplankton genera (J'>0.5). RL had J' values categorized as low (J'<5) with uneven dispersion of phytoplankton genera (Nurfadillah et al., 2022). Uneven distribution conditions cause the phytoplankton community to be vulnerable to the presence of dominant genera (Al-Thahaibawi et al., 2021).

Based on previous research, BL was reported to be heavily polluted with H' values in the range of 0.151-0.158 (Salam, 2010). Increasing H' in BL occurred as BL had undergone lake management by sediment dredging in 2019. According to Salam (2010), BL had a low DO level (3.13-5.62) before sediment dredging and it was increased as sediment dredging occurred (7±1.1). Phytoplankton was stressed before dredging the sediment due to low DO and H' levels, but after dredging DO and H' in BL increased. According to Cronberg (1982), sediment dredging decreases nutrient loading and increases the diversity of phytoplankton.

Phytoplankton indices pollution

Trophic and pollution degree based on Nygaard (In) values in the lakes ranged from 2.50-undefined. PJL had the smallest In value (2.50), which was categorized in slight eutrophication, otherwise, BL, GL, CL and PAML were undefined with high eutrophication. Saprobik (X) values ranged from 0.33-1.80. The highest X value occurred in PJL, which included in oligo/β-mesosaprobic phase with very slight pollution. The lowest X values occurred in BL and GL which indicated the β/α-mesosaprobic phase had moderate pollution (Table 6).

The In value was categorized as slight eutrophication and the X value indicated very slight pollution in PJL. Both these results were identified by low levels of BOD, PO_4-P and NO_3-N in PJL. PJL had a satisfying mixing process as the phytoplankton genus, which is a bioindicator for the low nutrient lake, i.e., *Pleurotaenium*, was found (Reynolds et al., 2002; Padisák et al., 2009). Otherwise, BL had high BOD and NO_3-N despite sediment dredging occurring in BL. Therefore, BL was categorized as having moderate pollution based on the X value. This occurred as a negative impact of sediment dredging, which produced secondary pollutants (Chen et al., 2021).

Moderate eutrophication based on the In value and slight pollution based on the X value occurred in RL. Anthropogenic activity around RL was high; it was supported by high-pollution tolerant phytoplankton genera, such as *Oscillatoria* and *Closterium*, being found in RL (Jafari & Gunale, 2006; Kshirsagar, 2013; Stamenković et al., 2021). Moderate eutrophication in RL occurred as a result of the anthropogenic activity around RL's increasing PO_4-P and NO_3-N levels. According to (Patil et al., 2012; Vicentin et al., 2018), high levels of PO_4-P and NO_3-N are an indication of eutrophication in a lake.

In values in PARL and KL were categorized as high eutrophication, furthermore In values in BL, GL, CL and PAML were undefined as the absences of Desmidiales in BL, GL, CL and PAML were observed. Undefined conditions indicate that high eutrophication occurred as Desmidiales were absent in BL, GL, CL and PAML. Generally, Desmidiales was the bioindicator for the oligotrophic lake (Jindal et al., 2014; Stamenković et al., 2021). Therefore, based on In values, PARL, BL, GL, KL, CL and PAML

Table 6. Nygaard and saprobic indices' values in 8 urban lakes in South Tangerang City.

Lakes	In	Trophic degree	X	Saprobic phase (pollution degree)
PJL	2.50	Slight eutrophication	1.80	Oligo/β-mesosaprobic (very slight pollution)
PARL	7.50	High eutrophication	1.00	β-mesosaprobic (slight Pollution)
RL	4.67	Moderate eutrophication	1.15	β-meso/oligosaprobic (slight pollution)
BL	Undefined	-	0.33	β/α-mesosaprobik (moderate pollution)
GL	Undefined	-	0.33	β/α-mesosaprobic (moderate pollution)
KL	11.00	High eutrophication	0.75	β-mesosaprobic (slight pollution)
CL	Undefined	-	0.45	β/α-mesosaprobic (moderate pollution)
PAML	Undefined	-	0.56	β-mesosaprobic (slight pollution)

were categorized as high eutrophic lakes. Otherwise, X values in PARL, KL and PAML indicated slight pollution has occurred. Different results from previous research observed moderate and heavy pollution in PARL and KL, respectively (Rijaluddin et al., 2017; Zharifa et al., 2019). Based on (Dresscher and Mark, 1976), incompatibility results of the saprobic index indicate that a heavy disruption in the environmental condition in the lakes occurred.

Inter-lake correlation based on Jaccard Index

Jaccard index values for inter-lakes were not equal to 1. CL and PAML formed a cluster with the highest Jaccard index value (0.62). PARL with KL and GL with RL formed a cluster with similar Jaccard index values (0.52). BL and PJL were separated and isolated from other lakes with low Jaccard index values (<0.5) (Figure 3).

Jaccard index values in the lakes (≠1) indicate there are no identical similarities in the composition and diversity of phytoplankton communities' inter-lakes (Cermeño et al., 2010; Vijayakumari et al., 2018). According to a report from Li et al. (2021), there were 4 similarity conditions based on Jaccard index values, i.e. extremely dissimilar (0>0,25), dissimilar (0,25>0,5), similar (0,5>0,75) and extremely similar (0,75>1). CL with PAML, PARL with KL and GL with RL had inter-lake similarities but BL and PJL were dissimilar with other lakes. According to Niyoyitungiye et al. (2020), environmental conditions, mainly chemical-physical variables conditions, impact the distribution of phytoplankton differently. JPL (PO_4-P and NO_3-N limitation) and BL (High pH and BOD level) had extreme chemical-physical variables conditions, which inhibited several phytoplankton genera's growth. They had no inter-lake similarities and they were isolated from the cluster.

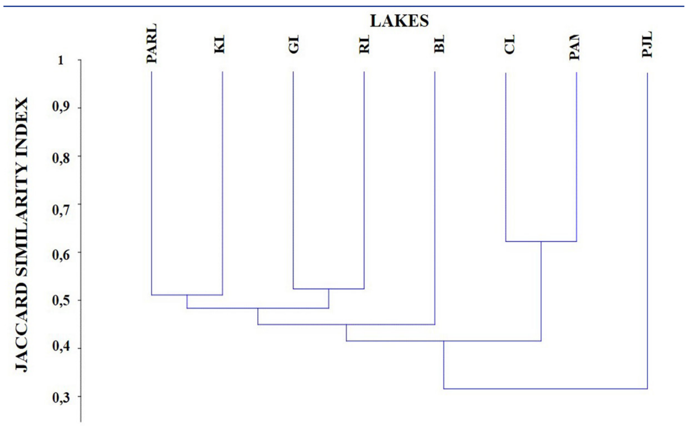

Figure 3. Inter-lake correlation in South Tangerang City.

Water variables and phytoplankton towards WQI

Based on Spearman's correlation results, the best correlation between the research variables and WQI were DO and BOD levels. DO levels indicated a moderate positive correlation with WQI values (r = 0.53), while indistinct with BOD levels indicated a strong negative correlation (r = -0.75). Phytoplankton abundances (A) indicated a low negative correlation with WQI values (r = -0.17) (Table 7).

A high BOD level is depleting DO level in the lake and harming aquatic ecosystems (Bhateria & Jain, 2016). Therefore, the decreasing DO level indicated deterioration of water quality by high BOD level. Meanwhile, a high DO level sustains aquatic organism respiration in the lake for respiration (Sulawesty & Aisyah, 2020). It also affirms the previous presumption, which indicated BOD and DO levels as the important factors for WQI. Phytoplankton abundance indicated a low negative correlation with WQI. It indicated an indirect interaction between phytoplankton abundance and water quality.

Table 7. Spearman's coefficient correlation results.

Variables		Wtemp	TDS	EC	SDD	TUR	pH	DO	BOD	PO_4-P	NO_3-N	A	WQI
							r						
Wtemp		1											
TDS		-0.29	1										
EC		-0.30	0.99	1									
SDD		-0.16	-0.06	-0.06	1								
TUR		0.21	-0.55	-0.53	-0.26	1							
pH	r	0.10	0.27	0.24	-0.29	-0.27	1						
DO		0.29	-0.28	-0.27	-0.03	0.31	0.04	1					
BOD		0.37	0.01	-0.04	0.14	0.18	-0.18	0.09	1				
PO_4-P		0.10	0.51	0.52	-0.03	-0.33	0.31	0.14	0.02	1			
NO_3-N		-0.08	-0.30	-0.33	-0.07	0.12	-0.08	-0.29	0.11	-0.55	1		
A		-0.06	0.55	0.58	-0.08	-0.36	0.02	-0.25	0.04	0.17	0.04	1	
WQI		-0.11	-0.20	-0.16	-0.09	-0.07	0.18	**0.53**	**-0.75**	0.06	-0.26	-0.17	1

Note: Bold = the best correlation coefficient with WQI results

CONCLUSIONS

The water quality of the lakes in South Tangerang City was not compatible with drinking water based on chemical-physical variables condition analysis. WQI values were categorized as a medium-good category. Based on phytoplankton composition, there was a domination of high-tolerant phytoplankton genera and classes in polluted waters. Phytoplankton communities were stable in the lakes in South Tangerang City, except for RL, which was vulnerable. Phytoplankton compositions between lakes were not identical based on the similarity index. Correlations of DO and BOD with WQI results were the best correlation. DO had the highest positive correlation, whilst BOD had the highest negative correlation. Sediment dredging needs to be done periodically and further improvement in lake management is required. Submerged macrophytes restoration is highly recommended for controlling Cyanophyceae's population.

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Ethics committee approval: Ethics committee approval was not required.

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