Phytoplankton diversity and functional group in three urban lakes of Cibinong, West Java, Indonesia

Sulastri1,* and I Akhdiana1

1 Research Centre for Limnology, Indonesian Institute of Sciences, Komplek LIPI Cibinong, Jl. Raya Bogor-Jakarta, Km 46, Cibinong, Indonesia

*Corresponding author: sulastri@limnologi.lipi.go.id

Abstract. Urban lakes are rapidly becoming vulnerable because of such as anthropogenic pollution and urbanization. Phytoplankton is classified as a biological indicator of lake status. Study was conducted to determined and compared diversity and functional group of phytoplankton including environmental factors in three urban lakes of Cibinong, West Java, Indonesia. The data was collected twice a month from July to October 2018. Three urban lakes showed a different water quality. Phytoplankton composition consists of Chlorophyta, Bacillariophyta, Chrysophyta, Cyanophyta, Pyrrhophyta, Cryptophyta and Euglenophyta division Chlorophyta is more diverse group than other divisions in those three urban lakes. High abundance of Chlorophyta was found in Situ Cibuntu. In Situ Lotus, high of abundance was represented by Bacillariophyta. Temporally, in August, the percentage abundance changes from Chlorophyta to Chrysophyta in Situ Dora. Based on the index diversity, Situ Dora is more stable habitat than Situ Cibuntu and Situ Lotus. The index diversity (H') and Evenness (J) value of Situ Dora, Cibuntu and Lotus, H': 1.41-4.03, J: 0.4-0.98; H’: 0.65-2.61; J: 0.2-0.76 and H’: 0.12-2.19, J: 0.11-0.57, respectively. The stability of habitat in Situ Dora was also indicated by the balance of phytoplankton functional group.

Keywords: diversity; phytoplankton; lake status

1. Introduction

Urban lakes locally called “Situ” is important freshwater resources to support the quality of human life by providing services such as water supply, recreation, educational activities, and socio-economic importance [1, 2]. Generally, urban lakes are shallow and have small size with the average depth of 3 to 5 m or less [3]. Their small water volume often causes unstable hydrological balance and sensitive to human impacts activities as increasing of nitrogen and phosphorus load from the watershed [3]. Therefore, urban lakes area tends to have high nutrient load and sensitive to the pollution and eutrophication.

In West Java, “Situ” has many functions such as used for water supply, recreation, and maintenance groundwater table. Situ also have important roles related to natural resources conservation since Situ or small lakes are habitat for great biodiversity [4], reserve the freshwater sources, and supporting socio-economic community [6]. More than 200 small lakes in West Java, particularly in area of Jakarta, Bogor, Depok, Tangerang and Bekasi (Jabodetabek) with the surface area ranges from 1 to 160 ha and the average of water depth 0.5 to 2 m [5, 6]. Currently, there are 96 small freshwater urban lakes in the area of Bogor and 23 small urban lakes are found in area of...
Cibinong [7]. Urban lakes in Jabodetabek are the most threatened ecosystem because of sedimentation, eutrophication, and pollution. Those damaged environmental condition of urban lakes was found in megacity of Jakarta due to land use change, untreated sewer, and stormwater runoff [8]. Bogor regency as a part of the Jakarta Metropolitan Area (Jabodetabek) has the same problems of urban lakes such as, sedimentation, pollution, and eutrophication. As a consequence, it needs an appropriate management practice to protect the capacity and function of this vulnerable ecosystem.

Aquatic ecosystem such as small lake or Situ is habitat of phytoplankton, which characterize the status of the aquatic ecosystem related to the productivity. Phytoplankton is part of food web system which has an important role in transferring energy to the higher trophic level in the aquatic system. However, high load of nutrients into the lake causes phytoplankton bloom. Phytoplankton is primary biotic communities sensitive to the change of nutrient load and water quality as a response to the condition of surrounding environment [9, 10]. Therefore, phytoplankton diversity and abundance are commonly used as biological indicators of water quality and trophic state in lakes [11]. Species diversity index of phytoplankton shows a different value in different environmental conditions [11].

Phytoplankton functional groups often used to evaluate the environmental conditions and ecological status in waters [12, 13]. There are 33 functional groups, classified based on alphanumeric codes, their survival strategies, tolerances, and sensitivities to the environmental condition [14]. Many studies have adopted a functional group of phytoplankton approach to understand changes in aquatic ecosystems [15, 16]. There are three urban small lakes in Cibinong, namely Situ Cibuntu, Situ Dora or Situ Cilalay, and Situ Lotus. These small three lakes have a different morphological, hydrological, and water quality characteristics [17]. Differentiation characteristics of those three lakes have substantial influence of phytoplankton assemblages, particularly the diversity and the functional group composition. Little is known about the variation of diversity index and functional groups of phytoplankton composition in unstable hydrological of small lake as Situ Cibuntu, Situ Dora, and Situ Lotus. The study was aimed to compare variation of diversity index and functional group composition of phytoplankton in Situ Cibuntu, Situ Lotus, and Situ Dora for supporting management practice of those three urban lakes.

2. Methods

Research area is in Situ Cibuntu, Situ Dora, and Situ Lotus located at Cibinong City, West Java Indonesia (figure 1). Cibinong is Capital City of Bogor regency, located between 106° 21' -107° 13' East and 6° 19’-6° 47 South (figure 1). Climate type in Cibinong is considerably high rain rainfall particularly in December, January, and February while lower rainfall was found in June, July, and August [18]. Situ Cibuntu, Situ Dora, and Situ Lotus area are 2.11; 1.31; 078 ha with the maximum depth are 1.20; 1.13 and 2.0 m respectively. Hydrologically Situ Cibuntu and Lotus receive water from streams while water source in Situ Dora from groundwater.

Samples of phytoplankton and water quality data including total nitrogen (TN), total phosphorus (TP) water temperature, pH, Dissolved Oxygen (DO), and conductivity data total dissolved solids (TDS) were collected twice a week at three or four sampling points from July to November 2018. Water quality (temperature, DO, pH, conductivity, and TDS) was measured using water quality checker (YSI) while TN and TP concentration were measured by using Brucine method and Ascorbic acid method respectively [19]. Water depth was examined by measurement of the Secchi depth.

Phytoplankton samples were obtained by filtering 2 L of water from the surface water through plankton net (40 μm mesh size) then preserved with 1% Lugol solution. Phytoplankton species was identified according to some references [20,21,22]. Quantitative of phytoplankton was analysed using the Lackey Drop Micro Transect method [19] (HPHA 1999). Diversity index (H’) was calculated using Shannon Weaner’s formula: H’ = - ∑ Pi In Pi where, Pi = Ni/N is the proportion of species in the community, Ni is number individual of species i, and N is total number of individuals [23]. Evenness index was calculated using formula: J=H’/ln S, where H’ is species diversity, S is number of species [24]. Phytoplankton functional group was classified according to [14, 25]. A canonical correspondence analysis (CCA) between environmental factors (independent variables), the percentage phytoplankton functional group abundance, and
sampling sites was performed to determine relationship between the functional group of phytoplankton and environmental factors.

Figure 1. Map of research location.

3. Result

3.1. Physical-chemical properties
Water depth in Situ Cibuntu, Situ Dora and Situ Lotus fluctuated during observation. In Situ Dora, the lower water depth was recorded in August, September and higher water depth was recorded in July, November, and December (figure 2). Water depth in Situ Cibuntu and Situ Lotus show a high variability during study period.

Figure 2. Maximum water depth.

The water physical-chemical properties of observed urban lakes are presented in table 1. The average of water temperature showed little variation among of lakes (Situ). The highest average value of Dissolved Oxygen (DO) and pH were recorded in Situ Cibuntu (8.35 mg.L⁻¹) and (6.74) while the lowest of DO and pH were recorded in Situ Dora (6.24 mg.L⁻¹) and (6.1). The highest average value of TDS and conductivity was in Situ Lotus and lowest average value was in Situ Cibuntu. The highest average value of TN concentration was found in Situ Cibuntu (0.856 mg.L⁻¹) while the lowest average
value was found in Situ Dora (0.027 mg.L\(^{-1}\)). The highest value of TP concentration was in Situ Lotus (0.856 mg.L\(^{-1}\)) where the lowest value was in Situ Cibuntu (0.027 mg.L\(^{-1}\)). Primary component analysis showed those three lakes have a different characteristics of water quality conditions. Situ Cibuntu was characterized by high temperature, DO, and TN, while Situ Dora was characterized by low DO and pH. In Situ Lotus, water quality was characterized by high value conductivity and TDS (figure 3) [26].

**Table 1. Physical-chemical properties.**

| Parameters   | Cibuntu     | Dora        | Lotus       |
|--------------|-------------|-------------|-------------|
| Temperature (°C) | Range 27.33-32.21 | 26.23-33.48 | 27.14-32.07 |
|              | Average 29.89  | 29.31  | 28.79       |
| DO (mg.L\(^{-1}\)) | Range 6.41-11.23 | 5.53-7.41 | 7.11-9.26  |
|              | Average 8.35  | 6.24   | 7.55        |
| pH           | Range 6.32-7.83 | 5.74-6.54 | 6.32-7.2   |
|              | Average 6.74  | 6.01   | 6.69        |
| TDS (mg.L\(^{-1}\)) | Range 21.4-38.03 | 33.64-48.5 | 35.25-68.32 |
|              | Average 34.37 | 37.88  | 55.36       |
| Conductivity (mS.cm\(^{-1}\)) | Range 0.035-0.067 | 0.055-0.075 | 0.056-0.122 |
|              | Average 0.056 | 0.061  | 0.091       |
| TN (mg.L\(^{-1}\)) | Range 0.022-1.486 | 0.206-1.201 | 0.520-1.022 |
|              | Average 0.856 | 0.556  | 0.741       |
| TP (mg.L\(^{-1}\)) | Range 0.010-0.052 | 0.010-0.083 | 0.001-0.069 |
|              | Average 0.027 | 0.038  | 0.056       |

**Figure 3.** Primary Component Analysis (PCA) of Situ Cibuntu (C), Situ Dora (D) and Situ Lotus (L) based on the temperature (Temp) DO, pH, conductivity (Cond), TDS, TN, and TP parameters [26].

3.2. *Phytoplankton diversity and abundance*

Chlorophyta, Bacillariophyta, Cyanophyta, Pyrrophyta, Cryptophyta, and Euglenophyta were commonly found in Situ Cibuntu, Situ Lotus, and Situ Dora. Chlorophyta is diverse of phytoplankton
recorded in those three lakes (figure 4). In Situ Dora high number of species was belong to Chlorophyta with number of species range from 14 to 34. Bacillariophyta (diatom) constitute the second-high proportion of number species either in Situ Cibuntu and Situ Lotus or Situ Dora. Chrysophyta, Pyrrophyta, and Cryptophyta only present in minor taxon during observation. The high number of species belong to Euglenophyta was only recorded in Lake Cibuntu on August.

Table 2. Total Species, Diversity index (H') and Evenness index (J').

|   | Special Number Index Biodiversity | Month       | 5 Jul | 17 Jul | 2 Aug | 23 Aug | 12 Sep | 27 Sep | 10 Oct |
|---|----------------------------------|-------------|-------|--------|-------|--------|--------|--------|--------|
| Cibuntu | Total species                     | 54          | 27    | 51     | 52    | 31     | 31     | 32     |
|       | H'                                | 0.89        | 0.65  | 1.67   | 1.41  | 1.19   | 2.61   | 2.54   |
|       | J'                                | 0.22        | 0.2   | 0.42   | 0.36  | 0.35   | 0.76   | 0.73   |
| Dora  | Total species                     | 45          | 26    | 32     | 33    | 43     | 24     | 62     |
|       | H'                                | 3.25        | 2.5   | 2.82   | 1.41  | 2.74   | 2.92   | 4.03   |
|       | J'                                | 0.85        | 0.77  | 0.81   | 0.4   | 0.73   | 0.92   | 0.98   |
| Lotus | Total species                     | 46          | 18    | 26     | 30    | 37     | 16     | 34     |
|       | H'                                | 2.19        | 0.81  | 0.69   | 0.39  | 0.64   | 0.12   | 0.48   |
|       | J'                                | 0.57        | 0.28  | 0.21   | 0.11  | 0.18   | 0.04   | 0.14   |

Figure 4. Number species for each division of phytoplankton.

The high number of total species was in Situ Dora (24-62) then Siru Cibuntu (27-54) while Situ Lotus has a lower number of species of phytoplankton (16-46) (table 2). Temporally, the total number of species showed variability during observation. The highest value of Diversity index (H') and Evenness index (J') was recorded in Situ Dora (H': 1.41 to 4.03) and (J': 0.4 to 0.98) (table 2).
lowest value of Diversity index (H’) and Evenness index (J’) was in Situ Lotus (H’: 0.12 to 2.19 and (J: 0.04 to 0.57). Temporally the highest value of H’ and J’ in L Dora was found in July and October while the lowest of H’ and J was in August. In Situ Cibuntu and Situ Lotus the value of H’ and J’ show a variability during observation. In Situ Cibuntu, the high species Diversity (H’) and Evenness index (J’) value was in September, October and the low species Diversity (H’) was in July. inversely, in Situ Lotus high of H’ and J’ was recorded in July and lower value of H’ and J was in September.

In terms of phytoplankton abundance, Chlorophyta show high abundance in Situ Cibuntu, while Bacillariophyta was high abundance in Situ Lotus during study period (figure 5). In Situ. Dora, the high phytoplankton abundance changes during study period. In this Situ, Chlorophyta was abundance in July and October while Chrysophyta was abundant in August and Cyanophyta was abundant in July. Phytoplankton abundance fluctuated during study period. In Situ Cibuntu, Chlorophyta was abundant in July, while in Situ Lotus Bachilariophyta was abundant in September (figure 5).

3.3. Functional group composition

The composition of functional group in Situ Cibuntu, Situ Dora, and Situ Lotus relatively similar which is consist of codon D, E, F, P, N, MP, J, Lo, Y, Wi, W2, T, SN. S1, S2, S3, H1, M. However, in term of the highest number of species and the percentage of abundance for each functional group was quite different among of lake (figure 6). In Situ Cibuntu, the highest number of species was belonging to codon J represented by some species such as *Pediastrum* spp., *Coelastrum* spp., *Ankistrodesmus* sp., *Scenedesmus* spp., *Crucigenia* spp., *Tetraedron* spp. and *Actinastrum* sp.. In Situ Dora, high number of species belonged to codon N represented by some species such as *Cosmarium* spp., *Euastrum* sp.,
Cylindrocystis sp., Pleurotaenium spp., Microstria spp.. In Situ Lotus, high number of species belong to codon MP represented some species such as of Navicula spp., Pinnularia spp., Nitzchia spp., Gomphonema spp., Surirella spp., Cymbella sp and Eunotia spp.. In term of percentage of abundance, codon P was dominant in Situ Cibuntu and Situ Lotus almost during the study period. Codon P in Lake Cibuntu was dominated by Staurastrum spp. while in Situ Lotus codon P was only dominated by one species of Aulacoseira granulata. In Situ Dora, Codon E represented by Dinobryon sp. shows a high percentage of abundance especially in August while in another period codon N was often recorded in a similar proportion, except in August. The functional group of phytoplankton in Situ Dora showed a balance in composition during study period (figure 6). In Situ Cibuntu, functional group composition showed a balance in September while in October Codon P was replaced by codon J and Lo. In Situ Dora, codon J increase in July 5 (figure 6). Canonical Correspondence Analysis (CCA) explained high percentage of Codon J and Lo related to high DO and TN, while high percentage of codon P and E related to conductivity and low TN (figure 7).

![Figure 6](image_url) **Figure 6.** Number species (A) and percentage abundance of functional group (A, B, C) of phytoplankton.
Figure 7. CCA of functional group (D, E, F, J, N, P, M, Y, W1, W2, Lo, MP) and environmental parameters (DO, pH, TDS, TN, TP, Temp = temperature, Cond = Conductivity) in Situ Cibuntu (C), Situ Dora (D) and Situ Lotus (L).

4. Discussion
The fluctuation of water depth in Situ Cibuntu, Situ Dora, and Situ Lotus is related to the season of the year which is water level which indicated water volume follow the precipitation event. Climate in Cibinong dry season or low rainfall was found in June, July, and August and the highest rainfall in December and January [18]. High variability of water depth in Situ Cibuntu and Situ Lotus indicates that water depth of those two lakes was influenced by water inflow from the stream. The differentiation of water quality such as higher TN in Cibuntu and higher TP, TDS, conductivity in Situ Lotus, and lower TP in Situ Dora could be related to the differentiation of water source. Urban land-use type associated with water quality in lakes. Watershed with high percentage of plantation show high concentration of TP in lake water and watershed with high percentage of agriculture show high concentration of TN in lake water [27]. This phenomenon similar with the water quality condition in Situ Cibuntu and Situ Lotus which receive water input from the streams indicated higher concentration of TP and TN in Situ compared to nutrient concentration in Situ Dora which receive water source. TDS value in Situ Lotus is still common found for freshwater lakes in range 50 to 250 mg.L⁻¹. The higher TDS in this lake may be related to the higher input of ion from the watershed. Fertilizer can add any ion and increase TDS in waters. Furthermore, higher conductivity value found in Situ Lotus could be related to higher of TDS [28].

Chlorophyta is commonly found for phytoplankton assemblage and has wide distribution in the inland water habitat [29]. The shallowness of small lakes as L. Cibuntu, Dora, and lotus, wind induced, and water circulation stimulates sediment benthic diatom suspension which indicated by high number of species from Bacillariophyta in these Situs. In Situ Dora high number of species from Chlorophyta was representative by species belong to desmids (Cosmarium spp, Micrasterias spp, Euastrum spp Pleurotaenia spp.). The desmids are commonly found in small lakes (Ponds) with low conductance and moderate of nutrient levels [29]. This characteristic environment was found in Situ Dora. The higher of phytoplankton index diversity (H') and evenness index (J') in Situ Dora compared to Situ Cibuntu and Situ Lotus indicated that Situ Dora is more stable habitat than the last two lakes.
Unstable habitat in Situ Cibuntu and Situ Lotus may be related to unstable hydrological conditions and other environmental factors such as water depth and water quality fluctuation (figure 2).

Water level fluctuations can influence the stability of environmental factors in aquatic ecosystems or lakes [30]. Situ Cibuntu and Situ Lotus receive water from stream which showed variability of water depth indicate unbalance hydrological and water volume. Hydrological regime also regulated phytoplankton growth through regulating thermal condition and nutrient availability [31]. Temporally, high H’ index and J’ index were recorded in periods of high water depth and inversely lower H’ index, and J’ was recorded in low water depth (table 2). The increased water level probably extent the habitat area of aquatic ecosystem which increases phytoplankton diversity. As reported that phytoplankton richness is related to the habitat size [32]. The difference in abundance and composition of phytoplankton among observed lakes (situ) related to the difference between physical and chemical characteristics. Morphological and hydrological characteristics of lakes influence water quality and phytoplankton growth in small lakes [31, 33]. Situ Cibuntu and Situ Lotus characterized by higher nutrient TN and TP show higher phytoplankton abundance while Situ Dora characterized by low TP, show lower phytoplankton abundance. It seems that fluctuation of water depth also influences the accumulation and dilution of phytoplankton abundance in observed situs. In Situ Cibuntu high abundance of phytoplankton was in low water depth periods and inversely low phytoplankton abundance was in high water depth periods (September, October).

Phytoplankton in Situ Cibuntu and Situ Lotus has dominated species Staurastrum sp. and Aulacoceira granulata, respectively (17). High Staurastrum sp. lakes was influenced by water turbulence [34] and Aulacoceira spp. also tolerant to water mixing and sensitive to the water column stratification [35, 14]. This phenomenon was suitable for small shallow lakes as Situ Cibuntu and Situ Lotus. Water circulation and mixing were often occurred because of wind-induced and input of water discharge in these lakes. In Situ Dora, Chrysophyta was in August 23 with Dinobryon sp. as a dominant species. The dominant of Chrysophyta may be related to the ability of this division to compete for limiting phosphorus in this period and allows them to achieve dominant over other phytoplankton groups [26, 31].

The dominant of functional group (Code P) is related to the succession of species Staurastrum sp., Aulacoceira granulata as a dominant species in Situ Cibuntu and Situ Lotus which is attributed to their ability adapted to water turbulence [14, 25] in shallow small lakes. Codon P is the most characteristic of phytoplankton which frequently dominates in continuous or semi continue eutrophic lake and sensitive to stratification and to silicate depletion [14, 25]. Furthermore, phytoplankton in eutrophic shallow lakes is frequently dominated by same functional group [16]. In Situ Cibuntu, codon J and codon Lo increase in October. Codon J is the most characteristic of phytoplankton dominant in a habitat as mixed shallow lake and rich of nutrient. [16, 14]. CCA analysis showed that high Codon P was recorded in high TP, while J and Lo were found in high DO and TN. In Situ Cibuntu, the balance of functional group composition was occurred on September 27, while in Situ Lotus was occurred on July 5 July. This phenomenon was in line with the high value of H’ (table 2) which indicates stable habitat in this period.

Based on the functional group composition, in Situ Dora show a balance during study period, except on August 23, codon E was dominant. The balance of functional group composition was in line with high value in index diversity (H’) which indicates stable habitat in this lake. The dominant of codon E may be related to change of environmental parameters as a nutrient (TN and TP) which showed low concentration of TN and TP on August 23 [26]. E. assemblage represented by Dinobryon sp. to be characteristic for small, shallow, and low nutrient [25].

5. Conclusion
Phytoplankton composition consists of Chlorophyta, Bacillariophyta, Chrysophyta, Cyanophyta, Pyrrhophyta, Cryptophyta and Euglenophyta division. Chlorophyta is more diverse group than other divisions in those three urban lakes. Temporally, high cellular abundance changes from Chlorophyta to Chrysophyta in Situ Dora. Based on the index diversity Situ Dora is more stable habitat than Situ
Cibuntu and Situ Lotus. Composition of phytoplankton functional group was quite similar among three urban lakes. However, in term of percentage abundance codon P which describes to be character for eutrophic, continuous, or semi-continuous mixing layer habitat was dominant in Situ Cibuntu and Situ Lotus almost during observation. Situ Lake Dora composition of functional group showed a balance during observation except in certain period codon E show higher percentage which describes for small, shallow and low nutrient

Acknowledgments
Funding support for this study providing by a research grant from Indonesian Government (DIPA-APBN) through Research Centre for Limnology, Indonesian Institute of Sciences. The authors wish to thank Dr. Lukman and MS. Eva for their supporting in field survey.

References
[1] Ladwig R, Furusato E, Kirillin G and Hinkelmann R 2018 Climate change demands adaptive Management of urban lakes: Model-Based assessment of management scenario for Lake Tegel (Berlin, Jerman) Water 10: 186
[2] Padisák J, Borics G, Fehér G, Grigorszky I, Oldal I, Schmidt A and Zábóň-Doma Z 2003 Dominant species, functional assemblages, and frequency of equilibrium phases in late summer phytoplankton assemblages in Hungarian small shallow lakes Hydrobiologia 502: 157–168
[3] Nesseli-Flores J 2008 Urban Lake: Ecosystem at Risk, Worthy of the Best Care Proc. of Taal 2007 12th World Lake Conference: 1333-1337
[4] Hadiaty RK 2011 Diversitas dan kehilangan jenis ikan di danau-danau Sungai Cisadane Ikhtiologi Indonesia (in Indonesia) 11(12):143-157
[5] Department Pekerjaan Umum 1986 Inventarisasi situ-situ di wilayah Jabotabek Bappeda Daerah Tingkat I Jawa Barat 94 p
[6] Sudiana T W 2018 Potensi Situ Jabotabeb Sebagai Waduk Resapan J. Air Indonesia 10(1): 23–33 (in Indonesia)
[7] Wahid, Rauf A, Krisanti M, Sumertajaya I M and Maryana N 2020 Aquatic insect assemblages in four urban lakes of Bogor, West Java, Indonesia Biodiversitas 21(7): 3047–3056
[8] Henny C and Meutia A A 2013 Urban Lakes in Megacity Jakarta: Risk and Management Plan for Future Sustainability Procedia Environ. Sci. 20: 737–746
[9] Pasztaleniec A 2016 An advanced phytoplankton trophic index: Test and validation with a nationwide lake survey in Poland International Int. Rev. Hydrobiol. 10: 20–35
[10] Reynolds C S 1984 Phytoplankton Periodicity: Interaction of form, function and environmental variability Freshwater Biol. 14: 111–142
[11] Shekhar R T, Kiran B R, Puttaiah E T, Shivaraj Y and Mahadevan K M 2008 Phytoankton as index of water quality with reference to industrial pollution J. Environ. Biol. 29: 233–236
[12] Padisák J, Borics G, Grigorszky I and Sörőczki-Pintér E 2006 Use of phytoplankton assemblage for monitoring ecological status of lakes within the Water Framework Directive: the assemblage index Hydrobiologia 553: 1–14
[13] Alves-de-Souza C, Menezes M and Huszar V 2006 Phytoplankton composition and functional groups in tropical humic coastal lagoon Brazil Act. Bot. Bras. 20(3): 701–708
[14] Reynold C S 2002 Review, Towards a functional classification of the freshwater phytoplankton. J. Plankton Res. 24(5): 417–428
[15] Abonyi A, Leitão M, Lançôn A M and Padisák J 2012 Phytoplankton functional groups as indicators of human impacts along the River Loire (France) Hydrobiologia 698: 233–249
[16] Borics G, Tóthmérész B, Lukács BA and Várbiró G 2012 Functional groups of phytoplankton shaping diversity of shallow lake ecosystems. Hydrobiologia 698(1): 251–262
[17] Sulastri, Akhdiana I and Khaerunissa N 2020 Phytoplankton and water quality of three small
lakes in Cibinong, West Java, Indonesia IOP Conf. Ser.: Earth Environ. Sci. 477 012016

[18] Perdinan, Adi R F, Yon Sugiaro Y, Arifah A, Arini E Y and Atmaja T 2017 Climate regionalization for main production areas of Indonesia: Case study of West Java LISAT IOP Publishing IOP Conf. Ser. Earth. Environ. Sci. 54 012031 doi:10.1088/1755-1315/54/1/012031

[19] APHA 1999 Standard methods for the examination of water and wastewater 20th edition American Public Health Association Washington 10–176 p

[20] Prescott G W 1951 Algae of the Western Great Lakes Area Cranbrook Institute of Science Bulletin No. 31. 949 pp

[21] Scott A M and Prescott G W 1961 Indonesian Desmid Hydrobiologia 17: 1–132

[22] Gell P A, Soneman J, Reid M A, Illman and Sincock A 1999 An Illustrated Key to Common Diatom Genera from Southern Australia (Cooperative Research Centre for Freshwater Ecology Australia) No. 36. 64 pp

[23] Shannon C E and Weaver's W 1949 The Mathematical Theory of Communications Urbana: University of Illinois Press 117 p

[24] Pielou E C 1966 The measurement of diversity of different types of biological collections J. Theor. Biol. 13: 131–144

[25] Padisák J, Luciane O, Crossetti and Naselli-Flores L 2009 Use and misuse in the application of the phytoplankton functional classification: a critical review with updates Hydrobiologia 621: 1–19

[26] Sulastri, Nasution S H and Akhdiana I 2020 Temporal Variation of Physico-chemical and Phytoplankton Composition of Three Urban Lakes in Cibinong, West Java, Indonesia (in press)

[27] Sulastri, Harsono E K, Suryono T and Ridwansyah I 2008 Land Use, Water Quality, and Phytoplankton Structure Community in Some Small Lakes West Jawa Oceanolog dan Limnologi di Indonesia (OLDI) 34(2): 307–322

[28] Bhateria R and Jain D 2016 Water quality assessment of lake water: a review Sustain. Water Resour. Manag. 2: 161–173

[29] Wehr J D and Sheath R G 2003 Introduction of Freshwater Algae In Freshwater Algae of North America. Ecology and Classification eds: JD Wehr and RG Sheath (USA: Academic Press) P: 1–9

[30] Kolding J and van Zwieten P A M 2012 Relative lake level fluctuations and their influence on productivity and resilience in tropical lakes and reservoirs Fish. Res. 115: 99–109

[31] Tolotti M, Boscaini A and Salmaso N 2010 Comparative analysis of phytoplankton pattern in modified lakes with contrasting hydrological feature Aquat. Sci. 72: 213–226

[32] Smith V H, Foster L B and Grover J B 2005 Plankton richness scales consistently from laboratory microcosm to the world’s oceans. Proc. Natl. Acad. Sci. 102: 4393–4396

[33] Huang J, Xu Q, Xi B, Wang X, Jia K, Huo S, Su J, Zhang T and Li C 2014 Effect of lake-basin morphological and hydrological characteristic on the eutrophication of shallow lakes in Eastern China J. of Great Lakes Res. 40(3): 666-674

[34] Reynold CS 1984 The Ecology of Phytoplankton New York: Cambridge University Press 384 pp

[35] Lund J W G 1965 The ecology of the freshwater phytoplankton Biological Reviews of the Cambridge Philosophical Society 40(2): 231-290