Phytoplankton communities as indicator of trophic state in some habitats of Batanghari River system in Sumatera Island, Indonesia

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Abstract. Deforestation, land use change, expansion of agriculture, which may have an impact water quality in Batanghari River habitat. Phytoplankton composition, abundance, diversity and functional group were observed to know the trophic and ecological status of Batanghari River habitats. Phytoplankton samples and water quality were collected in 2022 at eight sampling sites. The result showed that phytoplankton abundance ranges from 85 to 3264 individuals L^{-1} indicating medium to low productivity. Phytoplankton community included seven divisions as Bacillariophyta, Chrysophyta, Chlorophyta, Cyanophyta, Pyrrophyta, Euglenophyta and Cryptophyta. Euglenophyta, Pyrrophyta and Chlorophyta are dominant group contributing 63.3 %, 63.58%, and 82.98 % to Batang Tebo, Lake Teluk and Lake Toman station respectively. A high total number of species (58 to 60) was recorded in Lake Sigombak and Lake Teluk. Diversity index (H'), showed most habitats in Batanghari River were classified as moderate ecological stress. A higher diversity index (2.645), species richness index (4.141), similarity index (0.763), low conductivity, low TDS and high percentage of PFGs NA indicating healthier and mesotrophic waters was recorded in Lake Sigombak. Low of index diversity (1.658 to 1.715), index species richness (1.387 to 2.181), index similarity (0.488 to 0.661) and pH (1.34 to 2.55) were found in peat swamp.

1 Introduction

Over the past century, river have played an important role in human life. People depend on river for their livelihood needs such as for transportation, irrigation, drinking water, fisheries. However, rapid economic growth and socio development over the past century led to the degradation of river system. The intensified land use and in the watershed bring various pollutant into the waters leading to severe pollution of aquatic ecosystems [1] Forest degradation, agriculture activities and urban development are the main source of water quality in wetland [2]. Land use change could increase inflow of water, sediment, nutrients, and other materials to downstream, and can reduce water quality and aquatic habitat function [3]. Mining activity also led to change channel morphology and the substrate of river which directly affect biodiversity and river regime. Therefore, land use change has been known the major threat of aquatic organism and habitat function [4].

Batanghari River basin is the longest river in Sumatra with the area was estimated about 4.5 million hectares [5]. The watershed of Batanghari is located at Jambi Province, and part

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of the area (18 %) is located at West Sumatera, Indonesia. River Batanghari has an important function for local people's live in the surrounding area, including transportation, domestic water supply, agriculture irrigation, and fisheries. The large river of Batanghari River has various of morphological habitat types such as oxbow lake, main river, tributaries, flood plain lake, swamp forest and peat swamp which characterize the richness of diversity aquatic organism. Batanghari River is known as a hotspot of fish diversity with 297 fish species was recorded in this river [6]. Some habitat types such as oxbow lakes, tributaries, flood plain lake and swamp forest in Batanghari River are known as nurseries ground and feeding habitat of fish fauna [7, 8]. However, deforestation, extension of agriculture area in watershed, fish culture activity in flood plain lake may influence aquatic environment, trophic state, aquatic biodiversity and Batanghari River habitat [5, 9]. Mining activities was reported to change the landscape condition and influence Batanghari River waters condition [10].

Intensification of human activities in watershed have an effect on physicochemical in waters and other toxic substances which indirectly influence phytoplankton composition and population [1]. Land use with increasing human activities show elevated nutrient concentration in waters, that stimulate phytoplankton growth and support eutrophication or algal blooms [1]. Phytoplankton which are highly sensitive to the environmental changes are a primary producer in the aquatic ecosystem [11]. Changes in the environmental factors in waters can alter in the phytoplankton composition, species dominance and abundance [12]. Therefore, species dominant, their abundance, species richness and phytoplankton functional group are often used as indicators for trophic and ecological status of waters [12]. Phytoplankton functional group (PFGs) which characterize the environmental condition of waters and are commonly used to evaluate ecological status of lake [13]. The PFGs has been used for examining the effects of environmental conditions on phytoplankton in tropical floodplain [14].

Large river as Batanghari River has various types of habitat form along meandering rivers. They include main river, poll, oxbow lake, flood plain lake located at the middle to the down of river. The variety of river habitat serve as separated ecosystem based on morphological and hydrological regime. These separated ecosystems could have different characteristics physicochemical and biotic communities including phytoplankton. Previous studies of phytoplankton in Batanghari River habitat were conducted spatially which have not evaluated the information related to morphological and hydrological characteristics of habitat [15, 16]. As reported hydrological regime influence phytoplankton abundance, phytoplankton diversity and controlling productivity of flood plain lake [17]. Comparative study on phytoplankton communities and trophic condition between natural habitat and more polluted habitat in Batanghari River was also still limited. For management propose information related to reference site and characteristic of each typology habitat is needed to monitor and restore the Batanghari River habitats

Phytoplankton functional group (PFGs) is a group species of phytoplankton which have similar morphological, physiological and ecological traits [18]. PFGs describes habitat properties, environmental tolerance and trophic state [18, 19]. Phytoplankton species are grouped into 31 PFGs, and then revised into 33 PFGS with naming by alphanumeric codes [18, 19]. This study was aimed to assess the trophic and ecological status of some habitats type of Batanghari River through analysis of phytoplankton community structure and phytoplankton functional group. The result could be used as a basic data to monitor and support management effort of Batanghari River habitat.

2 Material and methods

Research was carried out at Batanghari River, Sumatra Island, Indonesia located between 100° 43’ 9.7’’ E - 104° 8’ 23.0’’ E and 0° 43’ 35.8’’ S - 2° 46’ 52.0’’ S (Fig. 1) [20]. Batanghari River is river in Sumatra Island with 870 km of the length and 44,028 km^2 of the catchment area. Topographically, this river is classified as highland located at the upper part of river, medium land, and low land lying at down part of river [20, 21].

The data including water quality and phytoplankton were collected in the surface waters from 8 sampling sites in September 2022. The data were collected at two or four sampling points for each station. The sampling station were selected based on the morphological, hydrological connectivity, surrounding area condition and type anthropogenic activities in the watershed. The physical description for each station as follow: St1 or Lake Sigombak (SIG) is more natural environment with forest in surrounding area located at the upper part of Batanghari River, St 2 or Batang tebo (TBO) is a sampling site with antrophogenic pressure such as mining activity and receive wates water from surrounding area. St3 or Lake Bangko (St 3) is a protected area, ST4 or Pijoan River (PJO) is a riverine habitat at tributary of Batanghari River, St5 or Arang Arang River (ARR) is riverine habitat in stream of peatland area, St6 or Lake Arang Arang (LAR) and St7 or Lake Toman (TOM) are low land flood plain lake at peat swamp area. St 8 Lake Teluk (TEL) is flood plain lake in urban area. The detail description of the sampling station is presented in Table 1.

Water temperature, pH, dissolved oxygen (DO), turbidity, conductivity and total dissolved solid (TDS) were measured *in Situ* with water quality checker (Horiba U-10). Total nitrogen (TN) was analyses using the persulphate digestion and brucine method [22], while total phosphorus (TP) was determined using persulphate digestion and the ascorbic acid method [22]. Phytoplankton samples were collected by passing 20 L of water through plankton net 40 µm mesh sized and preserved in 1% Lugol’s solution for taxonomical study.

Some references [23,24,25] was used to identify phytoplankton species. Phytoplankton was observed under an inverted microscope with a 400 x of magnification and the abundance was counted using a Sedgwick-Rafter counting chamber with 50 x 20 x 1 mm^3 size. The phytoplankton functional groups (PFGs) were classified by grouping of phytoplankton species which have similar typical habitat characteristic [18,19]. There are 39 PFGs, naming by alphanumeric codes which have similar typical habitat, survival strategy and sensitivity to the environment [18, 19].

Species diversity of phytoplankton was calculated using Shannon wiener diversity index formula as follow: $H' = -\sum P_i \ln P_i$. $P_i = N_i/N$ is the proportion of species *i* in the community while Ni is number individual of species *i* and N is total number of individuals [26]. Index of Evenness was calculated using Pielou evenness index’s formula as follow: $J' = H'/\ln S$. H’ is species diversity, while S is number of species [27]. Margalef’s richness index was calculated using formula: $d' = (S-1)/\ln N$. S is total number of species and N is total number of individuals [28]. The relationship between the phytoplankton and environmental variables ware analyses by Canonical correspondence analysis (CCA) using MPSP (Kovach Computing Service) program version 3.22

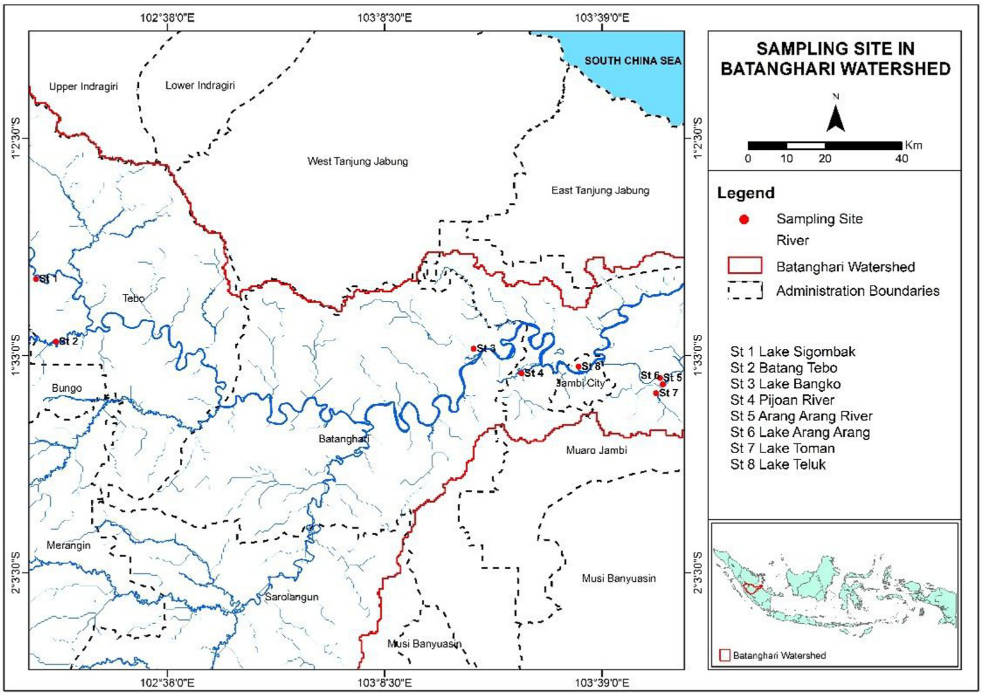

Fig. 1. Research location located at Batanghari River, Jambi Province in Sumatra Island, Indonesia.

Table 1. Name and description of sampling stations at Batanghari River.

Name of sampling Station	Code of sampling station	Description of sampling station
St1 (Lake Sigombak)	SIG	Oxbow lake connected to main river, 40 ha of surface area, surrounding area is forest area and used for fish culture activity. Located at the upper part of Batanghari River
St2 (Batang Tebo)	TBO	Riverine habitat at tributary; mining activities carried out; receive waste water from surrounding area.
St3 (Lake Bangko)	BKO	Flood plain lake located at tributaries, protected area within industrial forest plantation, located at 40 meters above sea level.
St4 (Pijoan River)	PJO	Riverine habitat, at tributary of Batanghari Rive
St5 (Arang Arang River)	ARR	Riverine habitat of stream that flow to tributary of Batanghari River, peat swamp water.
St6 (Lake Arang Arang)	LAR	Low land flood plain lake; connected to Batanghari River; peat swam; and 30 ha of surface area. Used for fish culture; surrounding area is palm oil plantation; domestic activities.
St7 (Lake Toman)	TOM	Low land flood plain lake, connected to streams that flow to tributary of Batanghari River, peat swamp.
St8 (Lake Teluk)	TEL	Flood plain lake, connected to the main river (Batanghari River) with 40 to 60 ha of surface area, located at town, surrounding area is settlement and the lake was used for fish culture activities

3 Result

3.1 Water quality

Physicochemical properties showed a spatial variability across the sampling sites (Table2). Temperature ranged from 23.31 to 31.24 °C which is commonly found in tropical area and still tolerable for aquatic organism. The optimal temperature for phytoplankton growth ranged from 20ºC to 30ºC [29]. The lower temperature 23.31ºC was recorded in BKO (Lake Bangko) which is located at industrial forest plantation. Potential of Hydrogen (pH) ranged from 1.34 to 6.88 showing acidic to slightly acidic waters condition. Higher pH was recorded in riverine habitat (TBO and PJO) while low pH (1.34 – 3.56) was recorded in peat swamp waters station (ARR, LAR and TOM). A high pH value found in TBO and PJO was also showed by high DO concentration (6.44 and 7.21 mg.L^{-1}). Low DO concentration was also found in ARR, LAR and (peat swamp waters). Conductivity value ranged from 7 to 31 µS.$^{-cm}$, while TDS ranged from 4.34 to 21 mg.L^{-1}. The conductivity value in Batanghari River system is similar to that in the middle part of Kapuas River ranging from 8.3 µS.$^{-cm}$ to 29 µS.$^{-cm}$ [30] The lowest conductivity and TDS were recorded in Lake Sigombak (SIG) which indicate low dissolved ion concentration in this station. Turbidity ranged from 0.9 to 215 NTU. High turbidity (208.5 to 215 NTU) was found in riverine habitat (TBO and PJO) while low turbidity in station ARR and flood plain lake station (LAR, and TOM). TN and TP concentration was commonly low, ranging from 0.244 mg.L^{-1} to 1.019 mg.L^{-1} and 0.004 to 0.037 mg.L^{-1}) respectively (Table 2). High TN concentration was found in Lake Arang Arang (LAR) while high TP concentration was found in Arang Arang Stream (ARR).

Table 2. Water quality in some habitat of Batanghari River.

Parameters	Station							
	SIG	**TBO**	**BKO**	**PJO**	**ARR**	**LAR**	**TOM**	**TEL**
Temperature (ºC)	30.23	28.61	23.31	29.8	27.68	31.24	28.84	30.06
pH	4.82	6.87	4.96	6.37	1.34	2.56	2.55	6.02
DO (mg.L^{-1})	6.19	6.44	4.94	7.21	3.27	4.685	4.7	5
Turbidity (NTU)	70.5	208.5	109.7	215	4.9	2.35	0.9	27.4
Conductivity (µS^{-cm})	7	18	19	23	13	26	31	25
TDS (mg.L^{-1})	4.4	11.5	12.5	15	0.02	16	0.021	16.5
TN (mg.L^{-1})	0.244	0.458	0.415	0.493	0.638	1.019	0.521	0.322
TP(mg.L^{-1})	0.005	0.005	0.006	0.01	0.037	0.007	0.013	0.004

3.2 Phytoplankton community and diversity

There were seven phytoplankton divisions found in Batanghari River habitats namely Bacillariophyta, Chlorophyta, Cyanophyta, Chrysophyta, Pyrrophyta, Euglenophyta and Cryptophyta. The dominance of phytoplankton composition showed a variability across the sampling sites. Chlorophyta contributes,52.91 %, 73.03 % and 82.98 % to Lake Sigombak (SIG), Lake Arang Arang (LAR) and Lake Toman (TOM) respectively, while Euglenophyta and Pyrrophyta contributes 63.3 % and 63.58% to Batang Tebo (TBO) and Lake Teluk (TEL) respectively (Fig.2). Phytoplankton abundance were found in varied spatially. Phytoplankton ranging from 91to 3264 individual.L^{-1} indicating low to moderate fertility waters **(**Table 3**).** High phytoplankton abundance indicating moderate waters fertility (1237 to 3264 individual.L^{-1}) were found in SIG, LAR and TEL stations while low phytoplankton abundance (85 to 301 individual.L^{-1}) was found in BKO, PJO, ARR, TOM stations . Number species and phytoplankton abundance were range from 11 to 64 (Table 3). A Low number of species was recorded in ARR and TOM while high number species was recorded in SIG and TEL.

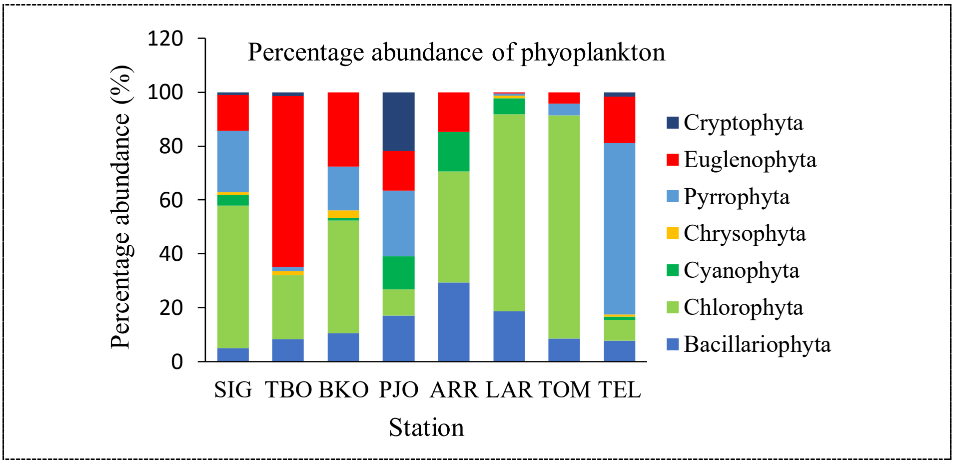

Fig.2. Percentage abundance of phytoplankton composition in observed station.

Table 3. Total number of species, average abundance of phytoplankton, diversity index, Margalef 'species Richness index and Pilou'evenness index in observed station.

Number species, abundance and diversity index of phytoplankton	**Station**							
	SIG	**TBO**	**BKO**	**PJO**	**ARR**	**LAR**	**TOM**	**TEL**
Total number of species	58	32	29	19	13	22	11	64
Total abundance (individual.L^{-1})	1985	301	132	85	91	1237	98	3264
Diversity index (H')	2.645	2.126	2.112	2.077	2.154	1.658	1.170	1.725
Margalef' species Richness (d')	4.141	2.645	2.968	4.047	2.203	1.837	2.181	3.155
Pielou'Evenness index (J')	0.763	0.918	0.769	0.705	0.593	0.661	0.488	0.535

Shannon diversity index (H'), Margalef'Species Richness (d') and Evenness index value are presented in Table 3. The value of index diversity, Margalef Species Richness and Evenness index was varied among stations. A higher Shannon diversity index and Margalef'species richness index was found in SIG, while a lower index diversity and Margalef'species species richness index was found in LAR and TOM station. A lower evenness index was recorded in TOM station and a higher evenness index was recorded in TBO station

Chlorophyta and Euglenophyta were recorded to have higher number of species compared to other phytoplankton division (Fig. 3). High number of species belong to Chlorophyta with the number 32 and 27 species which was recorded in SIG and TEL respectively, while TBO and TEL, 16 and 18 species of Euglenophyta were recoded respectively.

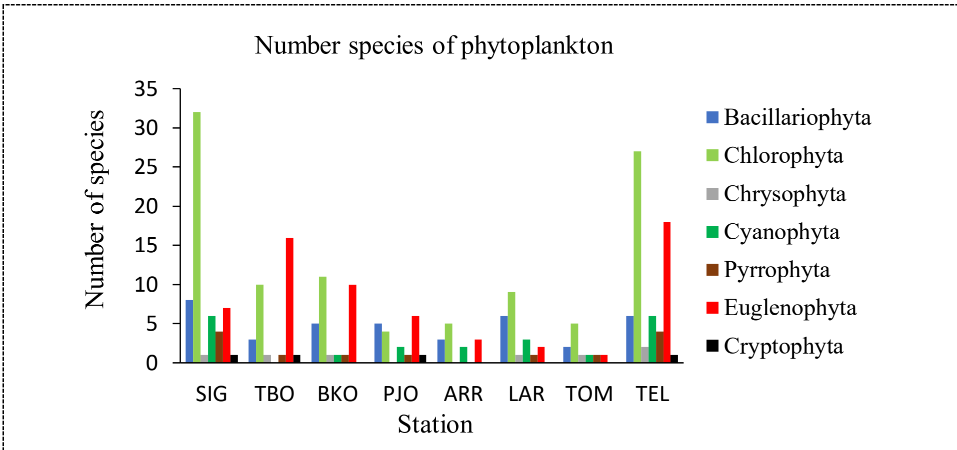

Fig. 3. Number species of phytoplankton in observed station.

The relationship between phytoplankton and water quality is presented in Fig.4 CCA analysis showed that water quality affected relative abundance of phytoplankton. Figure 4 show that high percentage of Chlorophyta and Cyanophyta abundance was related to TN, while high percentage abundance of Euglenophyta and Bacillariophyta was related to turbidity. High percentage abundance of Pyrrophyta was related to temperature.

3.3 Phytoplankton Functional Group (PFGs)

Based on the phytoplankton species composition, there were 18 PFGs code found in Batanghari River habitat, namely D, E, F, J, P, NA, Mp, H1, M, T, TC, TD, S1, SN, Lo, W1, W2, and Y (Table 4). Typical habitat characteristic, representative species and their distribution of each PFG were presented in Table 4. The dominant of representative species of each FPFGs and their distribution were different among the station (Fig. 5, Table 4**).** PFGs code of NA, MP, P, T and Lo groups were classified as dominant phytoplankton functional groups. PFGS code of NA was dominant in Lake Sigombak (SIG) with the main presentative species of *Staurastrum gutwinskii.* PFGs code of MP was dominant in TBO with the main species the main representative species of *Fragilaria* sp*.* PFGs code of P was dominant in Lake banko with the main representative of *Closterium quetzingii,* PFGs code of Lo was dominant in Lake Teluk (TEL) with the main representative specie*s of Peridinium cinctum* and *Peridinium getunense,* and PDFGs code of T was dominant in lake Arang Arang (ARR) with the main species *of Meugeotia* sp.

Percentage abundance of PFGs code of NA, Mp, P and Lo contributed 34.64 %, 43.18 %, 34.45 %, 60.13 % in SIG, TBO, BKO, TEL respectively, while PFGs of T contributed 32.36% ,50.82 % and 76.59% in ARR, LAR, TOM, respectively (Fig. 5). PFGs of W1 contributed 16.67 % and 13.39 % to TBO and BKO respectively, while PFGs of W2 contributed 15.87% and 21.16 % contributed to TBO to BKO respectively. Spatially, PFGs distribution in Batanghari habitat had marked variability (Table 4). PFGs code of D, P, Mp, Lo, W1 and W2 were commonly found in all of observation site

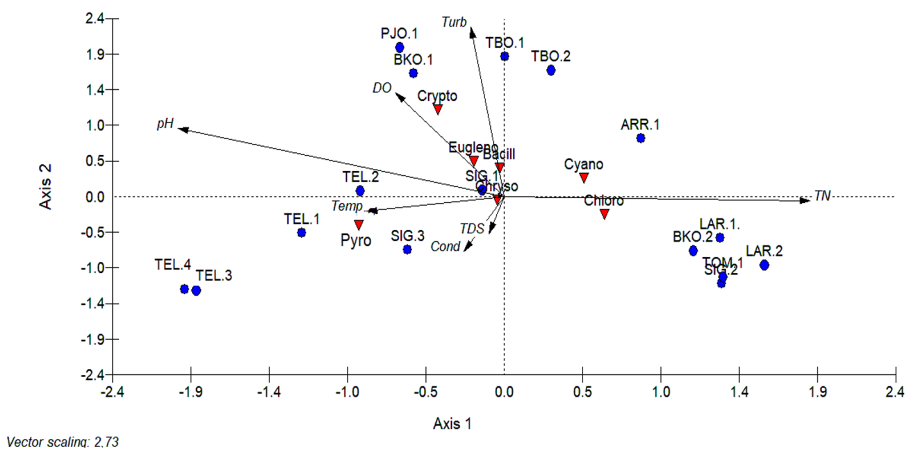

Fig. 4. Canonical component analysis of phytoplankton composition and environmental parameters in several stations (SGI, TBO, BKO, PJO, ARR, LAR, TOM, TEL). Phytoplankton composition: Chloro: Chlorophyta;Cyano:Cyanohyta; Chryso: Chrysophyta; Bacill: bacillariophyta; Eugleno: Euglenphyta; Crypto: Cryptophyta; Pyrro:Pyyrophyta. Water quality: Temp: Temperature; Cond: Conductivity; Turb:Turbidity; TDS, pH, DO, TN and TP.

Table 4. The functional group of phytoplankton, their typical habitat, species composition representation and distribution.

PFGs code	Typical Habitat characteristic for each PFGs [18,19]	Representative of species in station observation	Station
D	Shalow enriched turbid waters	*Diatoma elongatum, D. hymealis, Synedra ulna, Nitzschia* sp.	SIG, BKO, PJO, ARR, LAR, TOM TEL
F	Clear, deeply meso-eutrophic lakes	*Ankistrodesmus spiralis, Oocystis* sp., *Crucigenia* sp. , *Kirchnerilella* sp., *Sphaerocystis* sp. *Dyctiosphaerium* sp.	SIG, TEL
		Neospongiococum sp.	
J	Shallow, mixed, enriched waters	*Coelastrum* sp., *Crucigenia truncata*., *Scenedesmus bijuga*., *Pediastrum duplex, Tetraedron* spp. *Treubaria setigerum*	SIG; TBO; KBO, TEL
E	Small, shalow, poor lake	*Dinobryon* sp., *Centritractus* sp.	SIG, TBO, BKO, LAR, TEL
P	Shallow eutrophic lake with continues	*Aulacoseira granulata, Closteriopsis* sp.	TBO, BKO*, PJO, ARR, LAR, TOM, TEL.

	or semi continues mixed layer	*Closterium quetzingii*,* *Closterium* spp.	
NA	Oligo-mesotrophic lake	*Staurastrum gutwinskii*,* *Staurastrum* spp. *Cosmarium* sp,*,C. spinuliferum,* *Arthrodesmu spilophorus,* *Euastrum* sp.	SIG*, BKO, PJO, TOM, TEL.
Mp	Turbit shalow waters and frequently stirred up	*Cymbella* sp.,*Navicula* spp., *Pinnularia sp.,* *Pinnularia interupta.* *Fragillaria sp.,*	SIG, TBO; BKO; PJO; ARR; LAR; TEL
H1	Eutrophic lakes, low nitrogen	*Anabaena* sp.	SIG, LAR; TEL
M	Eutrophic to Hypereutrophic .	*Microcystis aeruginosa,*	SIG; TEL
T	Clear epilimnia deep lakes, mixed layer	*Spirogyra* sp. *Meugeotia** sp., *Ulotrix* sp., *Zygnema* sp. *Hyaloteca dissilience,* *Desmidium* sp., *Spondylosium sp.*	ARR*, LAR*, TOM*, TEL
TC	Eutrophic standing waters	*Oscillatoria* spp., *Phormidium* sp.	SIG; PJO; LAR, TOM, TEL
TD	Mesotrophic standing waters	*Cladophora* sp.	PJO; LAR; TOM
S1	Turbid mixed layer of waters.	*Planktotrix agardhii.* *Pseudoanabaena* sp.	SIG;PJO; LAR; TEL
SN	Warm mixed layer, tolerance low light and nitrogen deficient	*Cylindrospermopsis raciborskii*	SIG; TEL
Lo	Deep and shallow, oligo to eutrophic	*Merismopedia* sp., *Peridinium cinctum,** *Peridinium getunense*,* *Peridinium quadriden*	SIG; TBO; BKO; PJO; St7; TEL*
W1	Small lake, rich in organic matter	*Euglena proxyma * ,Euglena* spp, *Phacus* spp*	SIG;TBO*; BKO*, PJO*; St6; TOM; TEL
W2	Meso-eutrophic small lakes	*Traclelomonas volvonica*,* *Strobomonas* spp*. *Trachelomonas* spp*.	SIG; TBO*;BKO*;PJO*;LAR, TOM; TEL
Y	Wide range of habitat and almost all lentic ecosystem, tolerance low light	*Cryptomonas* sp.	SIG; TBO; BKO, PJO; TOM, TEL
G.	Nutrient rich condition in standing water	*Eudorina sp.*	TBO.

Remark *= main representative species at each station.

CCA analyses PFGs and water quality showed that the high percentage abundance of PFGs code NA related to low turbidity and inversely high percentage abundance of PFGs of P and MP was related to high turbidity (**Fig.6**). High percentage abundance of PFG of code

Lo, W1, W2 were related to pH and DO, while high percentage of T was related to TN, Conductivity and TDS. (Fig. 6)

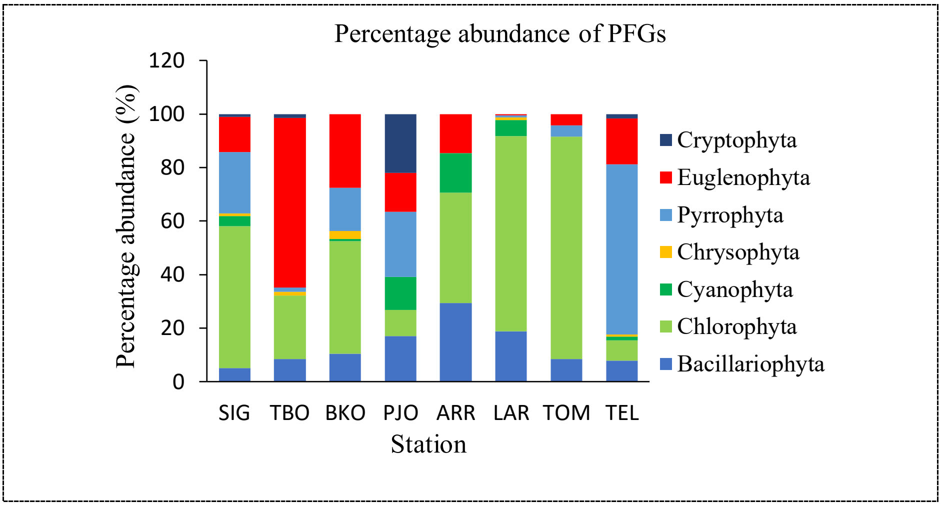

Fig. 5. Percentage abundance of phytoplankton functional group.

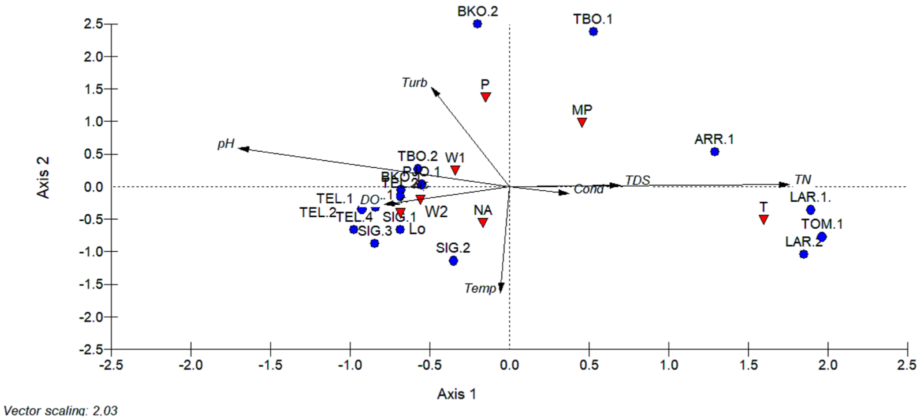

Fig. 6 Canonical component analysis of phytoplankton composition and environmental parameters in several stations (SIG, TBO, BKO, PJO, ARR, LAR, TOM, TEL). Phytoplankton Functional group: NA, P, MP, Lo, T, Wi, W2. Water quality; Temp:Temperature; Cond:Conductivity; Turb:Turbidity. TDS, pH, DO, TN and TP.

4 Discussion

Land use and human activity in watershed could influence the water quality status [31]. Low pH in ARR, LAR and TOM are commonly found in peat swamp waters [32, 33]. Higher DO concentration in TBO and PJO (riverine habitat) could be influenced by turbulence of river water. Flowing water in the river results turbulence which increase oxygen in water. Low DO in peat swamp waters was corelated with low pH in this station [32]. In general, DO concentration is still in range for fish survival and growth requirement with range (3.0 to 12 mg.L^{-1}) [29]. According to Goverment Regulation of Republic Indonesia [34], average DO concentration for fisheries activity is 4 mg.L^{-1}. Naturally, habitat with low DO is commonly found in peat swamp waters such as ARR, LAR and TOM. Low pH and DO concentration in these peat swamp waters were still tolerable for fish with the ability to adapt to low pH and DO to live in, because usually have additional breathing apparatus [35]. Low conductivity and TDS in SIG indicated that this station had low dissolved ion concentration. SIG or lake Sigombak is situated at the upper part of Batanghari River and surrounded by forest. Low human activity in the watershed resulted low input of dissolved ion into the lake. TDS source could come from, agriculture, domestic and industry activity [36]. High turbidity in TBO (208.5 NTU), BKO (109.7 NTU) and PJO (215 NTU) could be influenced by antrophogenic activites such as mining, forest plantation and agriculture activities in surrounding area and watershed. Turbidity was caused by the presence of suspended particles in water which could come from a variety of sources, such as soil erosion, industrial waste, and agriculture activity [37]. Low turbidity in ARR, LAR and TOM (0.9 to 4.9 NTU) may be because of those stations are not directly connected to the main river of Batanghari River which commonly bring higher suspended material. High TN and TP concentration in Lake Arang Arang (LAR) and Arang-Arang Stream (ARR) could related antrophogenic activity in watershed such as palm oil plantation [38]. Plantation practice and application fertilizer in the watershed could increase nutrient concentration in the waters [3].

The variability phytoplankton abundance could be influence by morphological, hydrological and physicochemical factors [39] Morphological related to depth and surface area, exerts influence on the stability of the water column and influence phytoplankton community and abundance in waters. Oxbow lake or flood plain lake characterized more stable waters and higher retention time cause phytoplankton in this habitat type is more settle and the abundance of phytoplankton is higher than phytoplankton in riverine habitat. On the other hand, lower phytoplankton abundance in floodplain lake such as BKO and TOM may be related to water quality such as turbidity and pH respectively. High turbidity in BKO could reduce light intensity and limit phytoplankton growth in this station, while low phytoplankton abundance at TOM may be only certain species could adapt to grow in low pH.

Phytoplankton is also sensitive to physical and chemical factors change due to their capability to respond antrophogenic load [40]. The response of phytoplankton to antrophogenic load or pollutant involved the change of Phytoplankton community structure [40]. Therefore, high percentage abundance of Euglenophyta in BTO (Batang Tebo River) indicated that BTO was polluted by organic matter. Euglenophyta is more tolerant to the contaminant such as organic matter and often used for organic matter pollution indicator [41]. Pollution sources in TBO could come from wastewater input and mining activity in their surrounding area. Canonical component analyses (CCA) showed that high percentage abundance of Euglenophyta is related to turbidity (Fig. 4). Another phytoplankton division such as Chlorophyta is typical phytoplankton division live in nutrient rich and shallow well-mixed waters [42]. CCA analysis also showed high percentage abundance of Chlorophyta was related to TN concentration (Fig. 4). This phenomenon coincided with the dominant of Chlorophyta and higher TN in ARR, LAR and TOM (Fig. 3). The higher number of species belong to Chlorophyta and Euglenophyta showed those phytoplankton group is tolerant to environmental condition habitat of Batanghari River). Euglenophyta and Chlorophyta is more tolerant to the contaminant [41]

Highest percentage abundance of Pyrrophyta was found in TEL (Lake Teluk). Canonical component analyses (CCA) showed that high percentage of Pyrrophyta is related to temperature (Fig. 4). A study reported that increase in Pyrrophyta biomass was positively correlated to temperature and organic matter [43]. High percentage of Pyrrophyta was dominated by *Peridinium cinctum* and *Peridinum getunense* species (Table 3). As a study reported, that the occurrence of *Peridinium cinctum* was associated with temperature, while peak abundance of *Peridinium* occurred during high load of organic matter [44]. TEL (Lake

Teluk) which is situated at lower part of Batanghari watershed and urban city of Jambi could receive high load of organic matter from the surrounding area.

Based on the diversity index (H'), most habitat in Batanghari River were classified as moderate ecological stress with values of 1.658 to 2.645. The values of diversity index above 3.0 indicate that the habitat is stable, while the values under 1.0 indicate that there is a degradation of the habitat [45]. The value of Margalef's richness index (d') ranged from 1.837 to 4.141 in the sampling site. Generally, for healthy environment, richness index ranges from 2.5 to 3.5 [28]. The highest Margalef's richness index (d') found in SIG (4,101) due to the diversity of Chlorophyta especially species from genera of *Staurastrum* which was commonly found in mesotrophic waters [19]. However, higher Margalef' species richness index in PJO (4.047) because of diversity of species belong to Euglenophyta which indicated by the waters was polluted by organic matter. A. Low index diversity and Lower Margalef'species index diversity in LAR and TOM because of the dominance *Mougeotia* sp. *Mougeotia* sp. is filamentous phytoplankton tolerant to the habitat with low pH [46]. Pielou's evenness index (J') described the equal distribution of the number of individuals at the community level. The values of evenness index (J') were between 0 and 1. Values that are closer to 1 indicate that these individuals are evenly distributed [47]. A higher evenness index (J') with the value of 0.918 was recorded in TBO indicating an even distribution of the species. A lower evenness index (J') with the value 0.488 to 0.611 found in ARR, LAR and TOM suggested that phytoplankton in those stations were not equally distributed and dominated by certain species such as *Mougeotia* sp.

The dominance and the occurrence of PFGs reflects the environmental degradation of waters except PFGs of NA. The dominant PFGs of NA in SIG indicate that this station was mesotrophic condition [19]. Dominant of PFGs NA is related to succession of *Sturastrum* species which commonly was found in mesotrophic waters. CCA analyses showed the dominant of NA was related to low turbidity (Fig. 5). As a study reported that *Staurastrum* prefer to live in clear waters [19]. Inversely the dominant of PFGs MP in TBO is related to succession of species from diatom such as *Navicula* spp., *Fragillaria* sp., which attributed by the ability adapted to turbid shallow waters with frequently stirred up (Table 4). This phenomenon made it suitable for TBO as a habitat characterized by high turbidity. The dominance of PFGs P is related to succession of *Closterium quetzingii, Closterium* spp., which are tolerances to low light intensity and C deficiency [18]. As reported that PFGs of P had relationship with turbidity and Z_{max} (maximum depth) [48]. This result was similar to our study that high percentage of PFGs P was related to turbidity. Therefore, the condition of BKO with high turbidity is still tolerable for *Closterium* growth. The dominance of PFGs T in ARR, LAR and TOM were related to succession species of *Meugotia* sp. which attributed by the ability to adapt to low pH [46]. Habitat of *Meugotia* sp is persistently mixed layer, including clear epilimnia of deep lakes, tolerance to light deficiency and sensitive to nutrient deficiency and [19]. CCA analysis also showed that high PFGs of T is related to high TN concentration. This phenomenon made it suitable habitat for St6 and St7 which was attributed by low pH and high TN concentration. The dominant of PFGs Lo was found in TEL with *Peridinium cinctum* and *Peridinium getunense* as the main representative species. PFGs Lo (*Peridinium* sp.) is a group prefers high concentration of dissolved oxygen in water [49]. Similar with our result, through CCA analyses showed that high percentage abundance of Lo was related to high DO concentration (Dissolved oxygen). These PFGs group had ability adapted to deep and shallow lake and tolerate oligo to eutrophic state [18]. In this study, turbidity, DO, pH, TN and TDS were the water quality parameters influence variation in phytoplankton functional groups composition and distribution.

5 Conclusion

The habitats of Batanghari River showed a varied of physicochemical characteristic, phytoplankton composition and abundance and diversity. In General, Batanghari river habitats show the environmental degradation and moderate ecological stress of waters except Lake Sigombak. Lake Sigombak was mesotrophic and more healthy condition based on the dominant of phytoplankton species, phytoplankton functional group, phytoplankton diversity and Margalef species richness. Ecologically, status of Lake Sigombak can be use as reference site in relation to manage the same typical habitat in Batanghari River.

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