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COMPARATIVE ANALYSIS OF PHYTOPLANKTON COMMUNITY IN SOME INLAND WATER HABITAT OF CENTRAL KALIMANTAN, INDONESIA

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Abstract
Analyses of phytoplankton community, species diversity and abundance for different types of inland water habitats were performed. Phytoplankton samples were collected during 1995 to 1997 in oxbow lake systems (Lakes Rengas, Lutan and Takapan), lowland lake (Lake Sembuluh) and river systems in the swamp forest (Tanjung Puting National Park). The analyses show that the dominant genera of phytoplankton were the groups belonging to Chlorophyceae and Bacillariophyceae. This fact was probably related to the acidic conditions (pH 4.42-5.55) at the study sites. The densities of *Closterium* and *Gonatozygon* were high at almost all sites while *Spirogyra* was dominant in Lakes Lutan and Takapan. The densities of *Navicula, Synedra* and *Tabellaria* were high at almost all sites. *Rhizosolenia* was found only in Lake Sembuluh at high density. The abundance of phytoplankton ranged between 232 to 3260 individuals/l, indicating low productivity of these inland waters. This fact was partly supported by the low dissolved oxygen concentrations (2.62-4.99 mg/l) at the study sites. It seems that there are two habitat types based on the number of phytoplankton genera. Lakes Rengas, Lutan and Takapan have higher number of genera than Lake Sembuluh and some riverine habitats in the forest area. Lake Lutan has the highest number of genera among the all habitats. On the other hand, Lake Sembuluh has lower number of genera but higher abundance of phytoplankton than Lake Lutan.
Key words: Oxbow lake, lowland lake, riverine habitat, phytoplankton community.

Introduction
In Central Kalimantan, inland water habitats include swamp forests, riverine forests, rivers and lakes. Sylvius (1986) has reported that the area of wetland habitat in Central Kalimantan is about 1,932,000 ha that is grouped into 940,000 ha of freshwater swamps, 872,000 ha of peat swamps, 100,000 ha of mangrove forests and 20,000 ha of freshwater lakes. The varaiety of inland water habitats which serve as separate ecosystems has characteristic vegetation or plant and animal species. These inland water habitats are ecologically important resources to the local people in Central Kalimantan such as fishery resources. In 1985, 19,000 ton of dried freshwater fish was exported from Kalimantan to Java, and 3,000 ton come from Central Kalimantan (MacKinnon *et al.* 1996). Studis on the ecosystem of inland waters of this area is very limited. Hartoto (1998) have developed some criteria to evaluate the success of fisheries reserves based on the limnological data.

Phytoplankton play an important role in inland water ecosystems. Virtually the dynamics of the lake ecosystem such as water color, clarity, trophic status or zooplankton and fish production depend to a large degree on phytoplankton (Goldman and Horn, 1983). Phytoplankton growth is affected by environmental conditions, such as transparency and some physicochemical conditions.

The present study was conducted to clarify community structure of phytoplankton in five inland water habitats and analyze the abundance, species richness diversity index of phytoplankton and the relation of the abundance to the water quality parameters.

Study Area.

The study was conducted in five inland water habitats. Those habitats include oxbow lakes that receive water either from the main river or from the tributary, or both from the main and tributary rivers, lowland lake and riverine habitat in forest area. Detailed information and the description of sampling sites are presented in Table 1.

Table 1. The characteristics of the sampling sites of inland water habitat in Central Kalimantan.

Habitat type	Name of sampling site	Global position	Description of sampling station.
A. Oxbow lake system that receives water from major river	Lake Lutan	S 2°09'12.4" E 113°55'14.7"	A fishery reserve which connecting to the Kahayan River with two small channels z_m: 5 m
B. Oxbow lake system that receive water from a tributary river	Lake Rengas	S 2°09'04.3" E 113°53'12.5"	A fishery reserve which is connected to the Rungan River, a tributary of the Kahayan River with two small channels. Zm: 9 m, and area: 35 ha.
C. Oxbow lake system that receive water from both main and tributary river.	Lake Takapan.	S 2°09'12.4" E 113°53'14.7"	A fishing ground connected to the Kahayan River and the Rungan River with more than small channel Zm: 15m.
D. Littoral and pelagic zones of lowland coastal lake (Lake Sembuluh)	Gulf of Telaga Bintang	S 2°42'15.3" E 112°21'40.0"	A fishery reserve, a gulf in the bay of Lake Sembuluh, a lot of *Pandanus* sp. plant. Zm: 3 m.
	Gulf of Batu Menangis	S 2°42'15.3" E 112°21'38.3"	Gulf of Lake Sembuluh, a lot of *Pandanus sp* plant, small island located at the mouth of the gulf. Zm: 3.2 m.
E. River segment in the swamp forest in the area of Tanjung Puting National Park	Natai Lengkuas of Sekonyer Simpang Kiri.	S 2°41'36.6" E 111°54'06.8"	A river segment with aquatic grass riparian, width: 25 m, Zm: 7 m, in the buffer zone of National Park.
	Pondok Ambung Sekonyer Simpang Kanan.	S 2°04'24.0" E 111°55'19.6"	A river segment with swamp forest riparian in the buffer zone of National Park, width 15 m, Zm: 2.5 m.
	Danau Panjang Sekonyer Simpang Kanan	S 2°54'05.3" E 111°41'38.9"	A river segment in the buffer zone of National Park, width: 15 m, Zm: 4 m flooded grassland riparian system
	Buluh Besar Estuarine segment	S 3°04'34.5" E 111°52'35.1"	A river segment in the core zone of National park , width 25 m, Zm: 4 m, nypa forest riparian system
	Buluh Besar upper segment	S 3°07'21.3" E 111°57'02.1"	A river segment in the core zone of National Park, width: 15 m, Zm: 10 m, swamp forest riparian.

Materials and Methods

Samples of phytoplankton were collected 12 times between 1995 and 1997. To have representative data, the data were obtained both for water quality and phytoplankton at least four or five sampling points in each inland water habitat. The sampling points in the oxbow lake system include pelagic zones and inlet and outlet of the lake. While in the lowland lake the sampling points include littoral and pelagic zones. Temperature, conductivity, transparency, water depth, turbidity, pH, dissolved oxygen were measured *in situ* using Horiba U-10 instrument. Water samples were collected in acid-PVC flasks and analyzed in Aquatic Dynamics Division Laboratory, Research and Development Centre for Limnology.

Phytoplankton samples were obtained by passing 30 l of composite water from surface to the bottom through a plankton net (number 25, 40 μm opening) and fixed in 1% Lugol's solution for taxonomical studies. Phytoplankton cells were counted under a binocular microscope using the Lackey drop microtransect method (Anonymous, 1977). The phytoplankton taxon was identified according to Scott and Prescott (1961) and Prescott (1970). Species diversity and equitability indices were calculated using the Shannon-Weaver equation (Odum, 1971).

Results and Discussion

At all the study sites the water was acidic with low pH and the dissolved oxygen concentration and conductivity were low. The conductivity in site E (riverine habitat) was higher than that at sites A, B, C, and D (oxbow lake systems and lowland lake). It was because this riverine habitat was closer to the brackish water system. Total nitrogen (T-N) values in Lakes Lutan, Rengas and Takapan (sites A, B, and C, respectively) were higher than those in Lake Sembuluh and the riverine habitat (sites D and E, respectively). Lakes Lutan, Rengas and Takapan are located in the Kahayan River system, indicating that the nitrogen concentrations in these lakes are affected by the nitrogen from the Kahayan River the water of which has higher nitrogen concentration

Table 2. The average values of physico-chemical parameters at the five sampling sites.

Parameter / sampling site	A	B	C	D	E
Depth (m)	4.01	5.01	4.3	3.21	3.44
Transparancy (cm)	35.20	40.71	35.36	120.2	92.94
Water temperature (°C)	28.9	28.0	28.07	29.38	26.51
Conductivity (mS/cm)	0.0173	0.0087	0.009	0.0065	0.9064
Turbidity (NTU)	84.02	22.13	72.42	7.025	12.71
Oxidative reductive potentials (ORP) (mV)	201.16	250.2	234	301.38	367.65
pH	5.55	4.45	4.86	4.83	4.42
Dissolved oxygen (mg/l)	2.62	2.73	3.04	4.99	2.906
$N\text{-}NO_2$ (μg/l)	5.615	4.14	4.262	0.0456	0.0155
$N\text{-}NO_3$ (mg/l)	0.561	1.024	0.435	0.751	1.149
$N\text{-}NH_3$ (μg/l)	118.55	225.2	128.9	0.944	0.948
Total nitrogen (mg/l)	5.521	5.319	5.420	1.467	1.467
Total phosphorous (mg/l)	0.972	0.448	0.516	1.211	0.814
TN/TP	23.53	21.67	26.53	4.64	4.49

because of the nitrogen inputs from the settlements along the river bank. Total phosphorous (T-P) concentrations in water of Lake Sembuluh (D) and the riverine systems in Tanjung Puting National Park (E) were higher than those of Lakes Lutan, Rengas and Takapan (A, B and C, respectively). The high value of T-P in Lake Sembuluh and the riverine system in Tanjung Puting National Park might be related to the existence of forests around the sites as source of phosphorus. The same phenomenon was also shown by the T-N/T-P ratio. Water of Lakes Rengas and Lutan Takapan had higher T-N/T-P ratio than that of Lake Sembuluh and the riverine system in Tanjung Puting National Park.

Table 3 shows the density and the number of genera in each sampling site. The densities of phytoplankton in some inland water habitats in Central Kalimantan or the area of study were low with the range of total individuals from 232 to 3620 individual/l, indicating that the phytoplankton of the study sites have low productivity. The low productivity was also confirmed by the low dissolved oxygen (DO) concentrations at the sampling sites. The conductivity values of study sites were low except for site E, indicating that the ion content was low at this site. Harris (1986) has referred to Lund (1955) that there is a positive relationship between the standing crop of phytoplankton and the concentrations of major ions. The lowest density of phytoplankton was found at site E although conductivity value was highest among the sites. Site E is located in a riverine or running water habitat so that the phytoplankton density may fluctuate very dynamically. The highest number of genera was observed in Lake Lutan (site A). However the density of phytoplankton in this lake was lower than that of Lake Sembuluh (site D) where the number of genera was lower than Lake Lutan. The number of genera found in Lake Rengas, Lake Lutan and Lake Takapan were 73, 72 and 64, respectively. On the other hand, the number of genera found in Lake Sembuluh and riverine systems in Tanjung Puting National Park were 50 and 23, respectively. The water quality data (Table 2) show that Lakes Lutan, Rengas and Takapan had higher T-N/T-P ratio than Lake Sembuluh and riverine system in Tanjung Puting National Park.

The species composition showed that desmid was the dominant group found at almost all sites at high densities especially for *Closterium* and *Gonatozygon*. The other dominant phytoplankton was a group of diatoms especially *Navicula*, *Synedra* and *Tabellaria*. Payne (1986) have reported that another group of green algae common in rather acidic water are desmids that often have constrictions at the center of the cells. It seems that diatoms are also common in low pH waters. There is a relationship between pH and composition of diatoms. The remains of diatom populations preserved in lake sediments have been used to reconstruct the history of acidification (Payne, 1986). Many diatoms are unable to grow under high pH (Jaworski *et al.*, 1981; Payne, 1986). Euglenophyceae was dominant at site A or Lake Lutan. Euglenophyceae show a preference for higher pH (Malatoni and Guillermo, 1996). Water of Lake Lutan showed the highest pH value (5.5) among the all sites. However, Euglenophyceae was also found in Lake Rengas (site B) and Lake Takapan (site C). Values of pH at these two sites were similar to those at Lake Sembuluh (site D) and riverine habitat in swamp forest (site E). Lakes Lutan, Rengas and Takapan are oxbow lakes of the Kahayan River system so that the densities of Euglenophyceae at these sites might have been affected by the phytoplankton from the Kahayan River. Dinophyceae were dominant in Lake Sembuluh (site D) and a few were found in Lake Rengas (site B) and Lake Takapan (site C). Dinophyceae is reported to show a preference for lentic environments (Malatoni and Guillermo, 1996).

Table 3. Taxonomical data of phytoplankton found at each sampling site.

Group / Sampling site	A	B	C	D	E
CYANOPHYCEAE					
Anabaena	8	163	97		
Aphanizomenon	1	11	2	2	2
Aphanocapsa	2		12	17	
Aphanothece		6	2	7	
Coelosphaerium	1				
Chroococcus	3	96	48		
Dichotrix			1		
Hapalosiphon	4				
Holopedium		1			
Lyngbya	1	55	10		
Merismopedia				3	
Microcaete		1			
Microcystis	4	11	52	25	
Nostoc	38	80	7		
Nodularia	1				
Oscillatoria	39	3	84	285	8
Phormidium	1	1			
Polycystis	2	1	29	6	12
Rivularia	2				
Spirulina	72	14	1	26	2
Sticosiphon	5.5		8		
Tolypothrix			16		
CHLOROPHYCEAE					
Actinastrum	1	9	6		
Ankistrodesmus	23	18		25	2
Basicladia	13	6			
Bambusina			2		
Chlamidomonas	39	5			
Characium		1	40	2	
Chaetophora	2	5		1	11
Cladophora	42	36	40		
Closterium	164	311	189	181	2
Cosmarium	27	4	75	54	
Crucigenia	3		6	3	
Desmidium	2	24	1	1	
Dermatophyton	1				
Dictyosphaerium		2	4	10	
Euastrum	1				
Exentrosphaeria			5		
Echinosphaerella		2			
Genicularia	3			1	2
Gloeocystis	7				
Gonatozygon	99	396	172	330	30
Hyalotheca	6		1		
Ichthyocercus	1				
Kirchneriella	6	23	50	13	
Lagerhemia	2				
Microspora		5			
Meugotia	1	24	1	9	11
Micrasterias	13	1	1	1	2

Table 3 (Continued)

Group / Sampling site	A	B	C	D	E
CHLOROPHYCEAE					
Netrium	2		2		1
Oedogonium	1	46	2		
Oocystis		263	169		
Ophyocytium			1	2	
Pediastrum	4		5		
Penium	2		4		
Pleurotaenium	11		2		
Protococcus				1	
Quadrigula	7		4		
Richtrella					2
Rhizoclonium	6	19			
Scenedesmus	7	19	10	47	
Spirotaenia			2		
Sphaerocystis	1			1	
Spondylosium	2				
Spirogyra	302	24	519	53	40
Staurastrum	3	4	4	196	
Tetraedron	51	12	3	1	
Tetraspora		1			
Triploceras		3	2		
Trochiscia	111	16	45		
Ulotrix	18	16	18	84	4
Volvox		1			
Xanthidium			1		
Zygnema	4	3	13	12	
Zygnemopsis			2		
BACILLARIOPHYCEAE					
Asteronella	18	70	1	1	
Achanthes	5		2	1	
Actinocyclus	8	2			
Centritractus	11	2			
Centronella			4		
Cyclotella	1	6	2		
Cymbella	5	4	14	11	
Coscinodiscus		2	5		
Coconeis	1				
Diatoma	20	99	48	7	4
Eunotia	29	15	19	10	
Fragillaria		22	54	3	
Frustulia		1			1
Gomphonema	4	1	2		
Gyrosigma		1	13	4	2
Meridion	9		12	3	
Melosira		1	1	16	
Navicula	10	199	826	212	33
Neidium		2			
Nitzschia	11	11	5	9	58
Pinnularia	2			1	1
Rhizosolenia				208	
Surirella	15	8	6	3	
Synedra	198	60	119	183	3

Table 3 (Continued)

Group / Sampling site	A	B	C	D	E
BACILLARIOPHYCEAE					
Stephanodiscus				1	
Tabellaria	48	121	218	218	1
CHRYSOPHYCEAE					
Dynobrion		5	2		
DINOPHYCEAE					
Glenodinium			1		
Peridinium		7	2	23	
EUGLENOPHYCEAE					
Euglena	77	7	15		
Phacus	66		7		
Trachelomonas	96	4	4		
Total phytoplankton (indivs./l)	1810	2342	3620	2314	232
Total genera	73	64	72	50	23

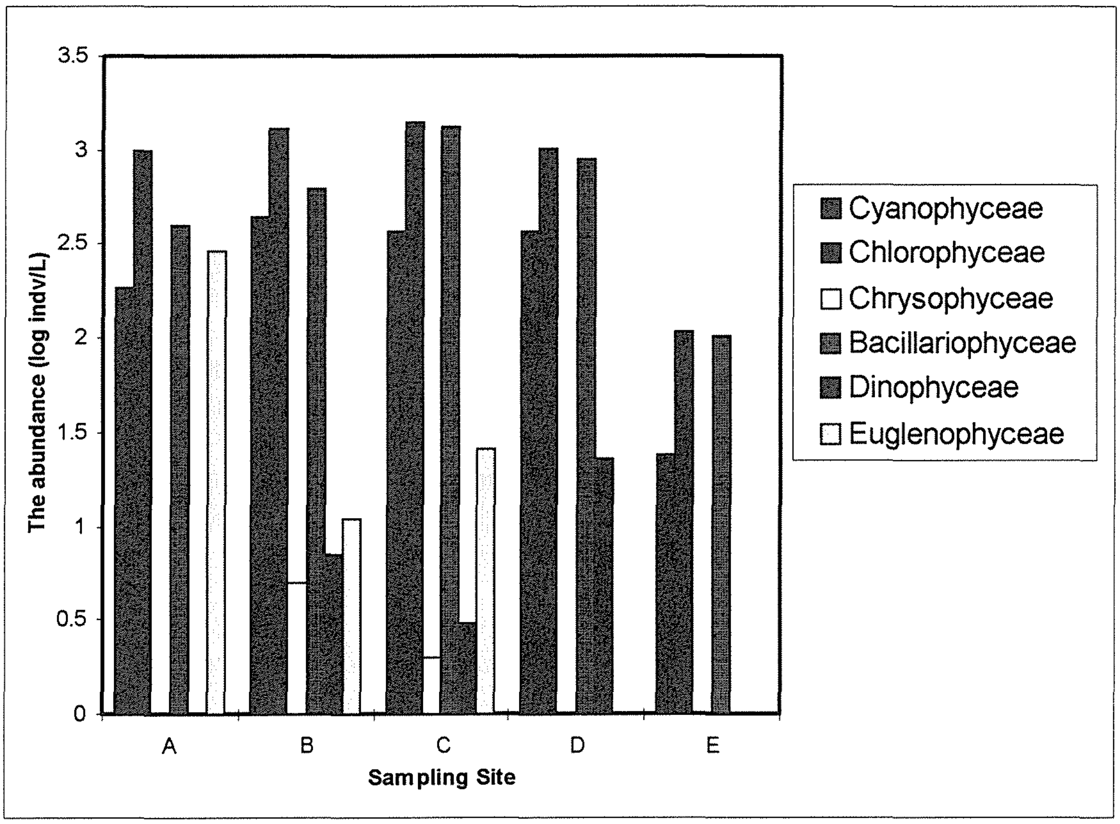

Fig. 1. The abundance of algae found at different sites in terms of taxonomic groups

The highest value of diversity index was found in Lake Lutan (site A) and the lowest value in Lake Sembuluh (site D). It seems that the condition of Lake Lutan was more stable than that of Lake Sembuluh. There were some seasonal or periodic perturbations by natural causes such as changes of water depth or water quality in Lake Sembuluh. Presumably only certain species could grow under such condition. It was also shown by the highest dominance value of species in Lake Sembuluh (site D) among the sites A to E (Table 4).

Table 4. Number of genera, diversity index, evenness and dominance of phytoplankton at different sampling sites

Index / Sampling site	A	B	C	D	E
Total genera (N)	73	64	72	50	23
Diversity index (H)	1.68 - 4.19	0.06 - 3.45	0.36 - 4.11	0.47 - 2.97	1.57 - 3.07
Average	2.95	2.23	2.38	2.04	2.28
Evenness (E)	0.63 - 0.95	0.11 - 0.96	0.23 - 0.98	0.71 - 1.00	0.71 - 0.90
Average	0.83	0.69	0.78	0.79	0.82
Dominance (D)	22.85-81.25	31.69 - 99.70	14.29 - 97.22	0.00 - 96.56	47.06- 99.94
Average	48.66	62.87	59.14	66.41	66.04

Conclusion

The density of phytoplankton in some inland water habitat in Central Kalimantan was relatively low, with the total phytoplankton density of 232-3620 individuals/l. The highest number of genera was found in Lake Lutan (site A) while the highest density found in Lake Takapan (site C). The water of these two lakes had higher pH values and T-N/T-P ratios. It seems that there are two habitat types in terms of number of genera and diversity in the inland water habitats. A correlation might exist between T-N/T-P ratio and species number or species diversity.

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References

Anonymous, 1975. *Standard Methods for the Examination of Water and Waste Water. 14th. Edition*. APHA-AWWA-WCR.

Bush, R. M. and Welch, E. B., 1972. Plankton associations and related factor in a hypereutrophic lake. *Water, Air and Soil Pollution,* 1: 257 - 274.

Goldman, C. R. and Horne, A.J., 1983. *Limnology*. McGraw Hill, London- Mexico- Sidney, 464 pp.

Hartoto,D. I., Sarnita, A. S., Sjafei, D. S., Awalina, Yustiawati, Sulastri, Kamal, M. M. and Siddik, J., 1998. Kriteria evaluasi Suaka Perikanan Perairan Darat. Puslitbang Limnologi-LIPI. 51 pp

MacKinnon, K., Hatt, G., Halim, H. and Mangalik, A., 1996. *The Ecology of Kalimantan. The Ecology of Indonesia Series. Volume III*. Periplus Editions (HK), Singapore, 802 pp.

Mataloni, G. and Tell, G., 1996. Comparative analysis of the phytoplankton communities of a peat bog from Tierra del Fuego (Argentina). *Hydrobiologia,* 325: 101-112.

Odum. E. P., 1971. *Fundamentals of Ecology. 3rd Edition.* W. B. Sounders, Philadelphia, 574 pp.

Payne, A. L., 1986. *The Ecology of Tropical Lakes and Rivers.* John Wiley and Sons, Chichester-New York-Toronto-Brisbane-Singapore. 301 pp.

Prescott, G. W., 1963. *The Freshwater Algae,* W.M. Brown Company, 347 pp.

Scott., A. M. and Prescott, G. W., 1961. *Indonesia Desmids. Hydrobiologia.* 17(1-2): 1-123.

Silvius. M. J., Djuharsa, E., Taufik, A. W., Steeman, A. P. J. M. and Berczy, E. T., 1986. *The Indonesian Wetland Inventory. A Preliminary Compilation of Existing Information on Wetlands of Indonesia.* PHPA-AWB/INTERWADER EDWN. Vol. II., Bogor, 268 pp.