PHOSPHORUS FINGER PRINTS OF LAKE SEMAYANG

DEDE IRVING HARTOTO
MUHAMMAD SUHAEMI SYAWAL
IWAN RIDWANSYAH
R&D Center for Limnology

ABSTRAK

A study to examine phosphorus finger print of Lake Semayang was conducted between July 1996 to January 1998. The objective of the study is to gather data bases on the relationship of terrestrial detritus input to fishery production. A Phosphorus finger print study can indicate the material input, trophic status, detritus dependency and organic distribution of aquatic systemt.

Direct measurements of parameter and water sampling were done in four stations. Chemical analyses of phosphorus species are conducted according to the method described in Standard Methods (1992). pH, water temperature and dissolved oxygen in monsoon season are decreasing according to increasing depth. Total-P concentration decreased from 675.2 ug/l in the dry season to 52.2 ug/l in rainy season due to dilution process. The results of finger prints for material input and trophic indicator examination indicate that Lake Semayang change from autochthonous lake in the dry season to allochthonous in rainy season. Results of production rate finger print indicate that primary production seemed to be control by the balance of wind scouring effects of the wind and orthophosphate sedimentation process of aerobic water. The organic material level of the lake also change from the one that are determined by wind scouring effects in the dry season to more detritus dependent in rainy season. Percentage of dissolved organic phosphorus is always high probably due to due to advanced fragmentation of organic detritus.

Key words: ***Lake Semayang, phosphorus, finger print, material input, trophic, production rate, detritus dependency, organic***

INTRODUCTION

Lake Semayang is a very large flood lake that receives water from Mahakam River. This oxbow lake has an area of 13000 hectares at high water time and already for many decades functions as a very important fishing ground for inland water fishers. Fish production from these inland water resources lately reported declining by Purnomo *et al.* (1993). Total productions of inland water fishery from East Kaliman tan mostly come from three big lakes, which are Semayang,

Melintang and Jeumpang. The production from these lakes indicated significantly lower compared to the 1970-1982 production reported by Christensen *et al.* (1986). The decline in fish yield suspected due to the deterioration of water quality as the impacts of many human activities; such as industry and uncontrol timber cutting; which end up to erosion and siltation.

Table 1. Characteristics of Sampling Sites at Lake Semayang

Station	Name of sampling sites	Description
1	Mouth of River Pela connection with L. Semayang	Maximum depth in the dry season 4.8 m Position: 0° 31' 53.8" S 116° 15' 09.5" E
2	Middles of the proposed "fisheries reserve,"	Maximum depth in the dry season 2.6 m Position: 0° 15' 14.5" S 116° 30' 54.3" E
3	Mouth of channel where the water flow from Lake Semayang to Lake Melintang	Maximum depth in the dry season 8 m Position: 0° 16' 18.0" S 116° 24' 44.7" E
4	Mouth of River Semayang flows to Lake Semayang (Gulf of Labanan)	Maximum depth in the dry season 1 m Position: 0° 11' 22.7" S 116° 27' 34.2" E

Subardja *et al.* (1998) reported that fish production in oxbow lakes of Kahayan River in Central Kalimantan strongly determined by allochthonous material input from terrestrial systems to adjacent aquatic systems. They also explained that the ichthyofauna food webs of the oxbow lakes are based on detrital food chain. It is interesting to know whether the fish production in Lake Semayang is also depends upon input of detritus material from its watershed. Initial steps in monitoring the relationships of fish production to terrestrial detritus input could be done by a study on "Phosphorus (P) Nutrient Finger Printing."

By understanding the nature of various states of existent of P nutrient, we can indicate present level input of allochthonous material. The phosphorus nutrient

finger prints will indicate any change in land use pattern of the watershed. In the above context, the aim of this study is to reveal the P-nutrient finger prints and general physical limnology condition of Lake Semayang at various sampling stations. Limnological condition of Lake Semayang represented by variation of parameters such as Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), pH, conductivity and water temperature.

MATERIALS AND METHODS

Sampling location

Lake Semayang located at Kotabangun District, Regency of Kutai, East Kalimantan Province. Sampling conducted two times, first in mid July 1996 as representative of dry season and the second times in January 1997 for rainy season. Observations and samplings were done at four stations. Characteristics of sampling stations are described in Table 1 and Figure 1.

At each sampling time, direct measurements of water quality parameters are taken. Water quality parameter such as Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), pH, water temperature and conductivity are taken 12 times

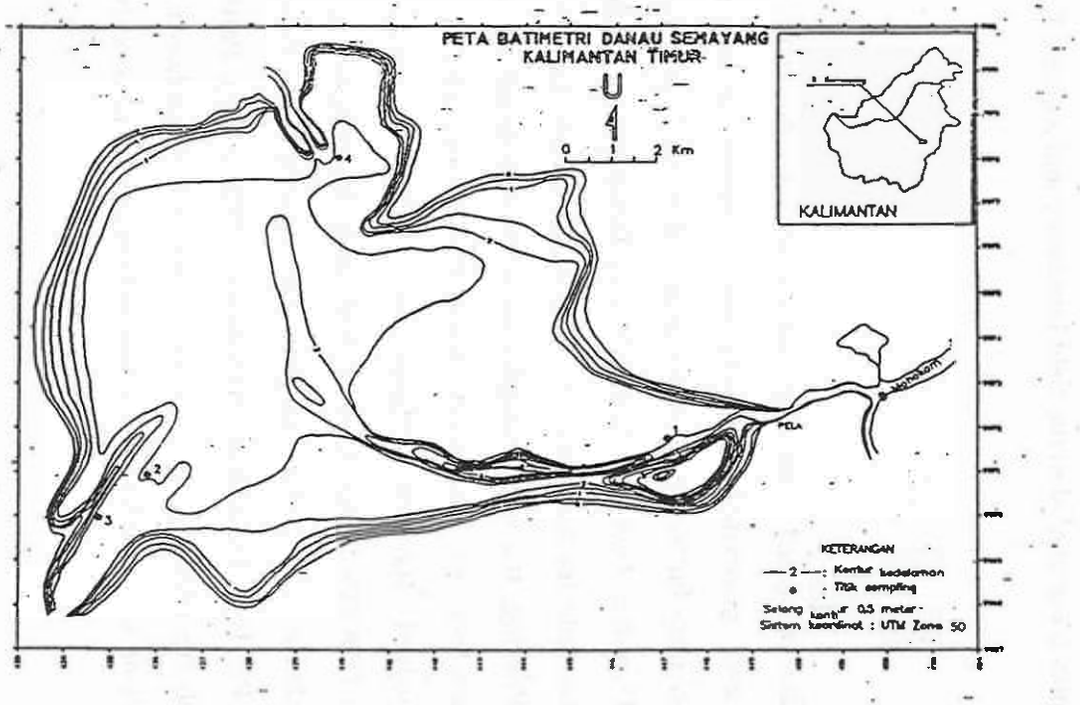


Figure 1. Position of sampling location in Lake Semayang (Source of bathimetric map is from Lukman *et al.* 1998).

randomly on the surface layer of the water. These measurements were done using Horiba Water Quality Checker. Beside that, at each sampling station, depth profiles analyses of some water quality parameters are also conducted. Water quality parameters such as pH, temperature, DO and conductivity of the water is recorded at every half meter interval started from the surface to the bottom layer. Surface and bottom layer water are sampled compositely at each station using Snatch Bottle sampler. The water samples are analyzed in the field laboratory and Aquatic Dynamic Laboratory.

Sample analysis.

Water samples are preserved, analyzed and calculated for CO_2, BOD_5, alkalinity, chlorophyll-a and suspended solid (SS). Some samples are immediately analyzed in the field laboratory but some other are analyzed in the Hydrochemistry Laboratory of Aquatic Dynamic Division, Research and Development Center for Limnology, Indonesian Institute for Sciences. In purpose to collect data on Phosphorus Nutrient Finger Printing, the water samples were also analyzed for several parameters. Those parameters are Dissolved Total Phosphorus (DTP), Total Phosphorus (TP), Dissolved Inorganic Phosphorus (DIP), Dissolved Acid Hydrolizable Phosphorus (DAHP), Total Acid Hydrolyzable Phosphorus (TAHP), Dissolved Organic Phosphorus (DOP), Total Organic Phosphorus(TOP), Particulate Organic Phosphorus (POP), Total Particulate Phosphorus (TPP or PP), Particulate Acid Hydrolizable Phosphorus (PAHP) and Particulate Inorganic Phosphorus (PIP). All preservations and analysis are according to the methods described in Greenberg *et al.* (1992).

The data collected in this study analyzed statistically using the methods described by Steel and Torrie (1960). A packet of computer program refers as MICROSTA is used for data analysis.

RESULTS AND DISCUSSION

General limnological condition

Table 2 presents the results of direct measurement of some parameters in Lake Semayang. From this table and statistical analysis we can observe that pH, dissolved oxygen, suspended solid and alkalinity levels tend to increase in monsoon season. The water may be carrying some basic compound that is capable to increase the hydroxyl ion in water. This phenomenon also indicated by higher alkalinity and suspended solid. The basic compound probably not of metal ionic group since the conductivity as the indicator of ionic content of a water mass tends to decreased in monsoon season. Lower chlorophyll-a concentrations in monsoon season indicate a poor phytoplankton community probably because of light penetration limitation due to more turbid water indicated by more than ten times higher suspended solid in rainy season. Ammonia and total nitrogen are also decreasing in rainy season. This pattern probably due to dilution of ammonia and total nitrogen already exists in the season by higher rainfall in this season. All the above pattern also observed in Lake Loa Kang that located near Lake Semayang (Hartoto, 1997).

Table 2. The Data of Water Quality Parameters Measurement of Lake Semayang.

Station	Season	Water quality parameters											
		pH	Water Temp. °C	Cond. mS/cm	ORP mV	DO mg/l	CO_2 mg/l	SS mg/l	Alka-linity mg/l*	BOD_5 mg/l	Chloro-phyll-a mg/l	NH_3 mg/l	Total-N mg/l
1	Dry	6.96	29.5	0.051	+ 181	7.24	6.97	2.24	2.53	2.13	2.69	0.016	4.788
	Monsoon	7.23	32.6	0.045	-	7.54	11.55	31.00	28.44	2.82	nd	0.001	0.467
2	Dry	6.98	29.4	0.050	+ 173	7.26	4.42	2.86	2.07	2.76	2.01	0.006	1.575
	Monsoon	7.30	32.1	0.042	-	7.43	10.63	26.50	29.15	1.85	nd	0.001	0.443
3	Dry	6.44	29.1	0.042	+ 141	5.88	8.81	2.48	2.67	1.99	2.32	0.011	6.739
	Monsoon	6.46	32.6	0.032	-	7.63	11.55	18.00	13.75	1.85	1.04	0.001	0.446
4	Dry	5.69	29.6	0.035	+ 237	2.71	4.42	3.26	1.87	3.00	1.99	0.005	1.437
	Monsoon	6.51	30.4	0.037	-	5.80	12.34	20.00	20.90	0.98	0.21	0.002	0.429

Note: - Missing data; * CaCO3 equivalent

Similarly to Lake Loa Kang (Hartoto, 1997) alkalinity of Lake Semayang (2.53-29.15 mg/l) is very low in comparison to criteria described by Swingle (1969). This act is also compromized with the very low chlorophyll-a level especially in the rainy season. Water quality parameter values differed significantly ($P < 0.05$) from station to station and from time to time. As could examined in Figure 1, these facts indicate that the morphologies of lake edge contribute to some extend to the variation of various parameters. Lake Semayang is a relatively shallow lake. In consequence the sediment probably has significant effect to the quality of water layer above it.

Parameter-depth profile

Table 3 presents the results of regression analysis between water quality parameter with depth. Only three among four of parameters' values are significantly correlated with depth. Those parameters are temperature, dissolved oxygen and pH. Even though this lake is a shallow one in monsoon season, combination data from all stations show that temperature decreases 1.82 °C for every one meter increase in depth. Values of dissolved oxygen and pH are also decreasing related to increasing depth. From these facts it is known that the dissolved oxygen in the water column probably originated from the oxygen pool in the atmosphere. Oxygen in the air solves to water through wind originated turbulence. Dissolved oxygen from photosynthetic activities is unlikely since the chlorophyll-a concentration in water is very low.

It is noted also that the deeper the water layer, the lower the pH. It seems that the water column nearest to bottom sediment, the water becomes more acid. A sediment study that evaluates the pH variations, organic acid and ammonia concentration are required to explain the above phenomenon.

Table 3. Regression Equation Resulted from the Depth Profile Analysis Conducted during Monsoon Season at Lake Semayang
(Number of Total Measurement, n =19)

Depth Profile of Parameters	Equation	Correla-tion Co-efficient (r)*	Partial regre-ssion coefficient (r^2)
Temperature-Depth Profile	Temp. (°C) = 30.96 - 1.82 Depth (m)	0.77	-
DO-Depth Profile	DO (mg/L) = 6.79 - 1.06 Depth (m)	0.58	-
pH-Depth Profile	pH = 6.87 - 0.31 Depth (m)	0.50	-
DO-Other parameter-Depth Profile	DO (mg/l) = -13.35 + 0.23 Depth (m) + 1.42 pH + 0.43 Temp. (°C) - 75.04 Cond. (mS/cm)	0.75	r^2_1=0.011 r^2_2=0.099 r^2_3=0.195 r^2_4=0.054

*: significantly correlated at $P < 0.05$, number of total measurement are 19

Phosphorus finger prints as indicators.

Finger print for material input indicator

Phosphorus finger print can be divided into five types. The first type is the one that refers as **P-finger print for material input indicator.** In this type, the

diagrampresents the percentages of total dissolved phosphorus (TDP) and total particulate phosphorus (PP) to Total Phosphorus (TP) concentration. This type of finger print is considered as the indicator of material input of a water body. Particulate phosphorus usually originated from inorganic eroded material from the watershed and organic material. The organic material can consist of living organism or remnant of organism whether the one in the aquatic systems itself or from terrestrial systems. Sources of dissolved phosphorus can consist of residues of orthophosphate fertilizer, domestic waste or industrial cleansing agents. Total dissolved phosphorus is a fraction of total-P that are capable to pass through 0.45 *u* filter paper (GFC). On the other hand the particulate phosphorus is the fraction that is retain by the filter paper. For relatively natural condition that exist in Lake Semayang, the sources of TOP are only fertilizer residues and domestic since in this area there is no industry that used phosphate cleansing compound.

The data in Table 4 and Figure 2 show that the percentages of TDP in the dry season nearly equal to PP, but the percentages significantly increase during monsoon. Only at the high tide of the dry season some small amount of the River Mahakam water can enter the lake. Phosphorus nutrient can rarely enter the lake from the outside of the aquatic systems. In this condition, nutrient for primary production mostly comes from autochthonous pools such as scouring of bottom sediment caused by wind effect. Further examination of Table 4 and Figure 2 shows that the total phosphorus (TP) in rainy season is significantly lower than its concentration in the dry season, probably due to dilution effect. Even though the T-P are significantly lower in rainy season, the percentages of total dissolved P increasing in all stations. The percentage of Particulate Phosphorus (PP) is de creasing in rainy season. It is likely that some particulate phosphorus solves into dissolved total phosphorus. Lake Semayang tend to change from autochthonous type the dry season to allochthonos in type lake in monsoon. Other factor that controls the existence of dissolved phosphorus is the redox condition of any water since in aerobic condition phosphate tend to be deposited simultaneously with iron deposition. In his report in 1941-1942, Mortimer lists the redox values of limnological important. In his list the oxidation and reduction of iron occur at 0.20-0.30 Volts (at pH =7) and its associated dissolved oxygen for iron deposition is> 0.1 mg/l. General limnological condition of

Lake Semayang reveals that orthophosphate tend to be deposited in the bottom sediment.

P-Finger print for trophic indicator.

The second type is of nutrient finger print is a pie diagram that shows the percentages of total phosphorus fractions to Total Phosphorus (TP). The total phosphorus fraction consisted of Total Organic Phosphorus (TOP), Total Inorganic

Table 4. Data for Phosphorus Nutrient Finger Printing of some Stations in Lake Semayang

Station	Season	Concentration of P-Nutrient fraction (*ug*/l) and its percentage relative to Total -P concentration											
		Type of Phosphorus nutrient finger print											
		Material input indicator			Trophic indicator			Production rate Indicator		Detritus dependency Indicator		Organic material indicator	
		TP *ug*/l (%)	TDP *ug*/l (%)	PP *ug*/l (%)	TIP *ug*/l (%)	TAHP *ug*/l (%)	TOP *ug*/l (%)	DIP *ug*/l (%)	PIP *ug*/l (%)	DAHP *ug*/l (%)	PAHP *ug*/l (%)	DOP *ug*/l (%)	POP *ug*/l (%)
1	Dry	758.9 (100.0)	178.6 (23.5)	580.3 (76.5)	5.1 (0.7)	569.6 (75.0)	184.2 (24.3)	3.0 (0.4)	2.1 (0.3)	147.9 (19.5)	421.7 (55.5)	27.7 (3.7)	156.5 (20.6)
	Monsoon	55.2 (100.0)	29.1 (52.7)	26.1 (47.3)	10.5 (19.0)	15.0 (27.2)	29.7 (53.8)	10.0 (18.1)	0.5 (0.9)	12.5 (22.6)	2.5 (4.5)	6.7 (12.1)	23.0 (41.7)
2	Dry	677.1 (100.0)	319.9 (47.2)	357.8 (52.8)	4.0 (0.6)	497.6 (73.5)	175.4 (25.9)	2.4 (0.4)	1.6 (0.2)	182.6 (27.0)	315.0 (46.5)	134.9 (19.9)	40.5 (6.0)
	Monsoon	71.9 (100.0)	43.2 (60.1)	28.7 (39.9)	10.5 (14.6)	17.3 (24.1)	44.1 (61.3)	10.0 (13.9)	0.5 (0.7)	11.8 (16.4)	5.5 (7.6)	21.4 (29.8)	22.7 (31.6)
3	Dry	654.7 (100.0)	372.0 (56.8)	282.7 (43.2)	3.5 (0.5)	381.2 (58.2)	270.0 (41.2)	2.4 (0.4)	1.1 (0.2)	143.6 (21.9)	237.6 (36.3)	226.0 (34.5)	44.0 (6.7)
	Monsoon	34.3 (100.0)	29.6 (86.3)	4.7 (13.7)	10.2 (29.7)	20.0 (58.0)	4.2 (12.2)	9.8 (28.6)	0.4 (1.1)	16.3 (47.5)	3.7 (10.5)	3.5 (10.2)	0.7 (2.0)
4	Dry	610.1 (100.0)	401.8 (65.9)	208.3 (34.1)	3.5 (0.6)	322.8 (52.9)	283.8 (46.5)	3.5 (0.6)	0.0 (0.0)	123.1 (20.2)	199.7 (32.7)	275.2 (45.1)	8.6 (1.4)
	Monsoon	47.4 (100.0)	41.9 (88.4)	5.4 (11.4)	10.3 (21.7)	18.1 (38.2)	19.0 (40.1)	9.9 (21.1)	0.4 (0.6)	13.9 (29.3)	4.2 (8.9)	18.1 (38.2)	0.9 (1.9)
Average value for the lake	Dry	675.2 (100.0)	318.1 (48.3)	357.1 (51.7)	4.0 (0.6)	442.7 (64.9)	228.5 (34.5)	2.8 (0.4)	1.2 (0.2)	149.3 (22.1)	293.4 (42.8)	166.0 (25.8)	62.4 (8.7)
	Monsoon	52.2 (100.0)	36.0 (71.9)	16.2 (28.1)	10.4 (21.3)	17.6 (36.9)	24.2 (41.9)	10.0 (20.4)	0.4 (0.9)	13.6 (29.0)	4.0 (7.9)	12.4 (22.6)	11.8 (19.3)

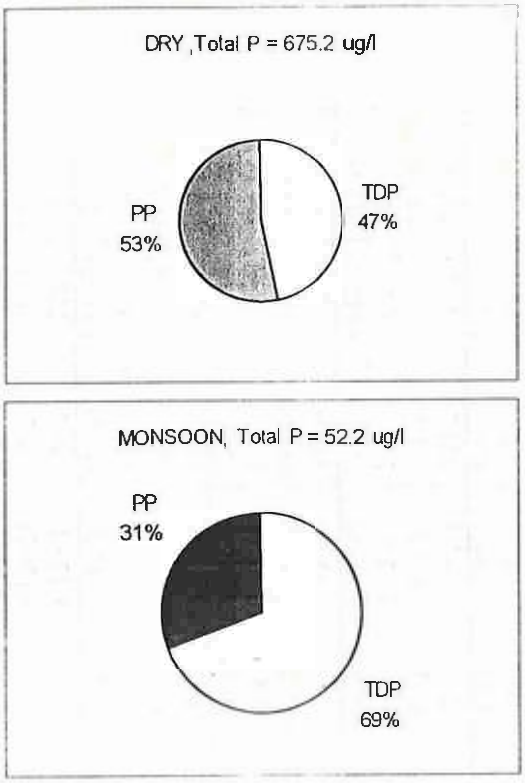


Figure 2. P finger print for material input indicator of Lake Semayang

Phosphorus (TIP) and Total Acid Hydrolizable phosphorus (TAHP). This type of phosphorus finger print later refers **as P-finger print for trophic indicator** that example is shown in Figure 3.

The data in Table 4 and Figure 3 indicate highest percentage of TAHP in the dry season follow by TOP but the TIP is the lowest. When in rainy season, the percentage of TAHP is decreased and the highest fraction is found in TOP, follow by TAHP and TIP. There is a significant increase in the percentage of TIP which in conformity with the decrease in TAHP percentage. Higher percentage of TAHP indicates that in rainy season there is an input of organic-P to Lake Semayang, possibly originated from detritus carried by surface run off during the rain. As for the condition indicated by P-finger printing for material input indicator, the above facts also testify that Lake Semayang turn more allochthonous lake type in the monsoon. In other words, Lake Semayang is a lake that its organic productivity dependent to detritus in rainy season.

P- finger print for production rate indicator

Production Rate indicator is the third type of P finger print. In this type of finger print the diagram show the percentages of Dissolved Inorganic Phosphorus (DIP) and Particulate Inorganic Phosphorus (PIP) to Total Inorganic Phosphorus (TIP). In Lake Semayang (Table 4 and Figure 4) the percentage of DIP is increasing in rainy season and consequently the PIP is decreasing.

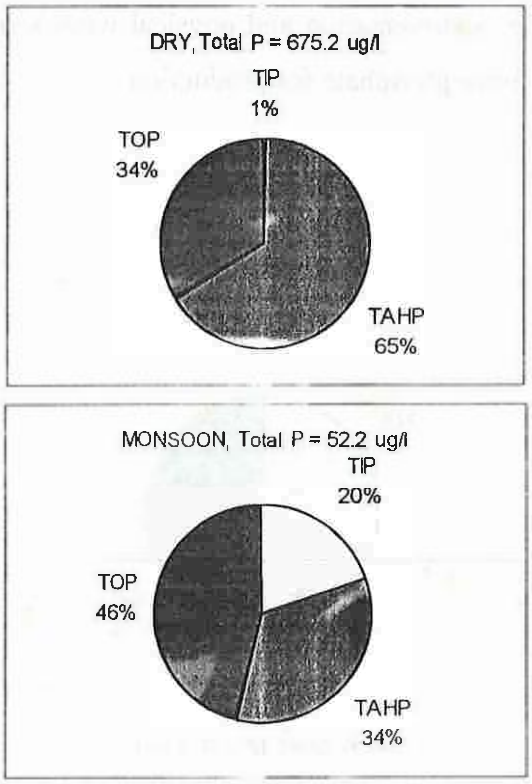


Figure 3.P-finger print for trophic indicator of Lake Semayang

Dissolved Inorganic Phosphorus represents the soluble reactive phosphorus that is capable to be used immediately by living vegetation. In other words, dissolved inorganic phosphorus is a representation of primary production capacity of any water. As the consequence; this type of P-finger print is an indicator of water potentials for its utilization as media for photosynthesis by living flora component of any aquatic systems. According to Cole (1975) only traces of orthophosphate are

found in the water when photosynthesis is continuing at a good rate. Payne (1986) also stated that inorganic nitrogen and phosphorus are often present in negligible concentration in tropical water even when considerable production is taking place. There was good evidence that orthophosphate was absorbed rapidly by the phytoplankton and transfered, presumably by sedimentation. The facts are not always as simple as that. Lower DIP percentage in aquatic systems not always means the water is capable to support phytoplankton photosynthesis. If the chlorophyll-a concentration is low but DIP concentration is low too, it is likely that there occurs sedimentation of orthophosphate especially in aerobic water. It deemed that in Lake Semayang sedimentation and physical wind scouring effects maintain the level of available orthophosphate for production.

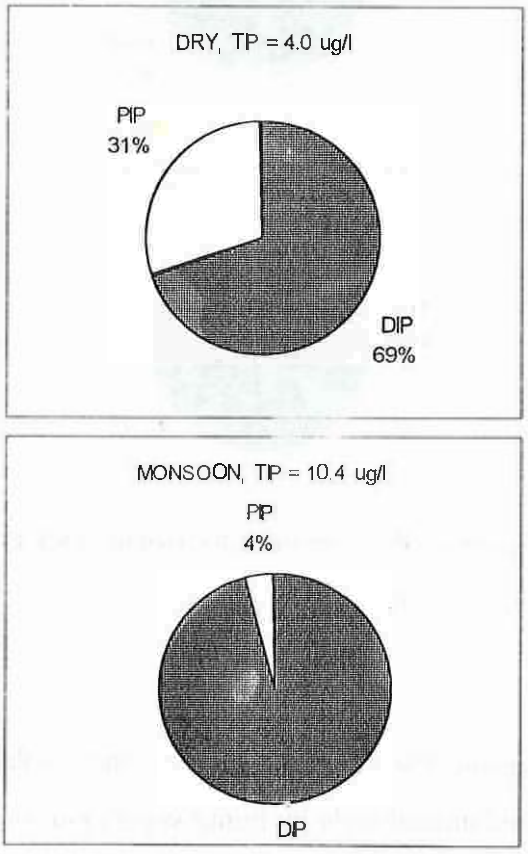
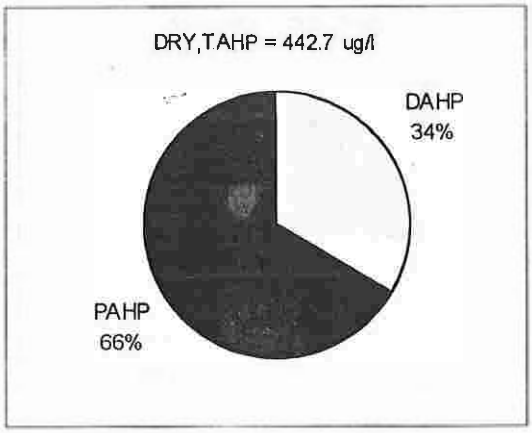


Figure 4. P-finger print for production rate indicator of Lake Semayang

P-finger print for detritus dependency indicator

The acid hydrolizable-P finger print or the **P-finger print for detritus dependency indicator** is name refers to finger print of the fourth type. In this finger print, the diagram shows the percentages of dissolved and particulate acid hydrolizable phosphorus to total acid hydrolizable phosphorus component of a water body. Acid Hydrolizable fraction of phosphorus represents the organically bound P that is already experienced partial decomposition or demineralization process. As already well understood in limnology literature (Goldman & Horne, 1983; Cole, 1975; Ruttner, 1953) that dead organism remnants have a role as suitable media for microbes which function as decomposing agents of this organic material. Particulate Acid Hydrolizable P fractions indicate the level of partially decomposed organically bound-P that has diameter larger than 0.45 *u*m. In more advanced decomposition process, the organically bound **P** will decrease in size and solve into solution (< 0.45 *u*m diameter) but the phosphorus atoms still weakly bound to organic compound. The data in Table 4 and Figure 5 shows that in Lake Semayang the percentages of DAHP increasing in rainy season but the PAHP decreasing. About the last discussion, it can be deducted that it is probably some of the terrestrial detritus (PAHP) already in the lake are decomposed farther into smaller size (DAHP) in early rainy season, but new inputof terrestrial detritus is not significant.



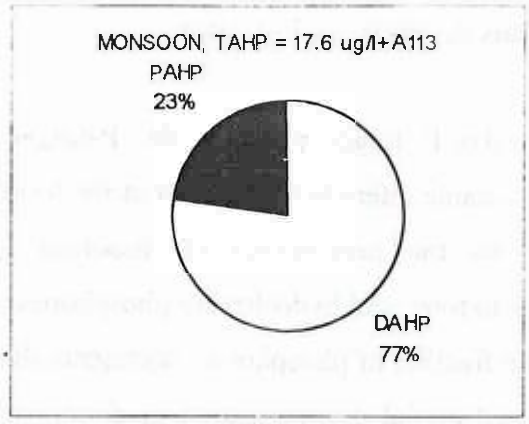
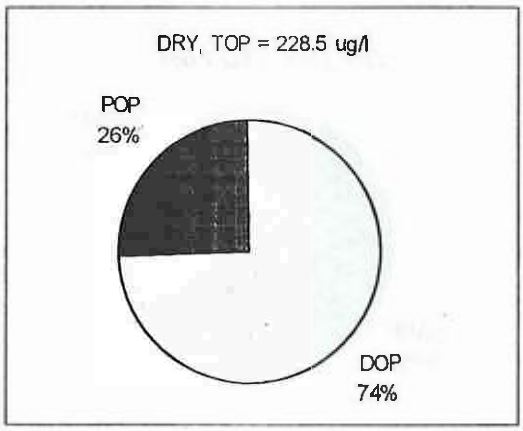


Figure 5. Finger print for detritus dependency indicator of Lake Semayang

Organic material indicator

The last type of finger print is the **P-finger print for the organic material indicator.** In this finger print, the pie diagram shows the percentages of DOP and POP concentrations to Total Organic Phosphorus concentration. The data in Table 4 and the diagram in Figure 6 shows that the DOP is always high whether in the dry or rainy season. Lake Semayang is a big lake; so riparian vegetation only has little influence. It is assumed that most of the DOP is originated from the POP that are already experienced advanced decomposition process; in this occasion the fragmentation process. On that, it can be concluded that the origin of organic phosphorus is from River Mahakam.



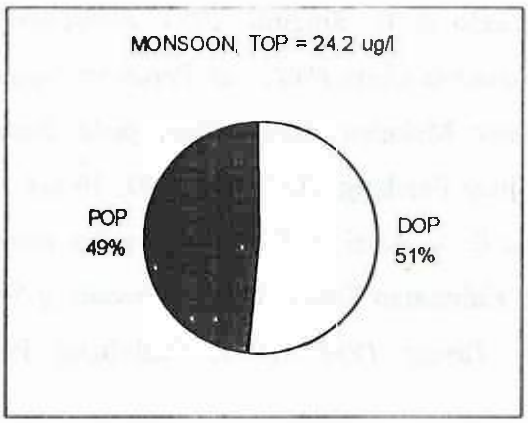


Figure 6. P-finger print for organic material indicator of Lake Semayang

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