THE WATER QUALITY ASSESSMENT AT GAJAH MUNGKUR RESERVOIR

Agus Djoko Utomo[1] , M.Rasyid Ridho[2], Dinar DA Putranto[3]
& Edward Saleh[4]

ABSTRACT

Gajah Mungkur Reservoir has a strategic potency and multipurpose use ecologically as well as economically. Aside from its function for the life of aquatic organisms it also serves for transportation, fishery, agriculture and tourism. At present the sustainability of water function of the reservoir is disturbed by problems such as sedimentation, pollution, eutrophication as well as change in function of the land at the upper stream of the river. The location of the study was carried out at Gajah Mungkur Reservoir Centre Java from March - November 2009. The aim of this study was to estimate parameters value of the physical, chemical and its trophic status of Gajah Mungkur Reservoir. The water temperature, dissolved oxygen, and carbon dioxide content of Gajah Mungkur Reservoir during the observation were in the range of 26 - 32°C , 07.11 and 0-13.2 mg/l mg/l respectively. Water temperature and dissolved oxygen tended to decrease with an increasing in water depth while carbon dioxide behaved inversely. Based on the fertility classification of average TRIX Index was 5,6; the productivity of the Gajah Mungkur Reservoir has reached eutrophic level.

Keywords: *Water quality, physical, chemical, reservoir*

INTRODUCTION

One of the water resources in Indonesia is a reservoir which has a strategic potency and multipurpose use ecologically as well as economically. A side from its function for the life of aquatic organisms it also serves for transportation,household needs, industry, agriculture and tourism. At present the sustainability of water function of the reservoir is threated due to sedimentation,pollution, eutrophication as well as change in function of the land at the upper stream of the river.

Gajah Mungkur reservoir at the Solo River was constructed in 1981 with surface water area and water depth of 8.800 ha and 140 m below sea level. It is located at Wonogiri District, central Java. Gajah Mungkur Reservoir, a multipurpose reservoir, situated at Wonogiri district with maximum water depth 29 meter and its main function is :o generate hydroelectric power and irrigation . In its development, the main utilization is not only for hydroelectric power, but at present also serves for additional activities such as fisheries (cage culture), transportation and tourism. Total cage culture operations were 740 cages registered in the fisheries service district. The main issue in the management of the reservoir ecosystem is the quantitative as well as qualitative environmental problem which occurred as a result of interaction between economic activities and existence of the nature resources

[1]*Research Institute for Inland Fisheries &*
Doctoral student of Environtmental science, University of Sriwijaya
[2]*Mathematic and Science Faculty, University of Sriwijaya*
[3]*Civil Engineering Faculty, University of Sriwijaya*
[4]*Agricultural Faculty, University Of Sriwijaya*

The problem encountered by Reservoir is eutrophication originating from anthrophogenic factors such as agricultural, domestic and industrial wastes, as well internal factor such as floating cage culture. It is estimated that the organic waste coming from cage culture at Saguling Reservoir reached 10.952 ton/year, while at Cirata and Juanda Reservoirs 148.782 ton/year and 3.125 ton/year, respectively (Garno, 2001).

To formulate the policy on sustainable water resources development at Gajah Mungkur Reservoir for present as well as future, the main problems and challenges should betaken into account. Important factors causing the above mentioned problems is a big gap between carrying capacity of the water resources to the number of requests, mainly for aquaculture (cage culture) and other needs;

The aims of the research is to study the water quality assessment at Gajah Mungkur Reservoir

MATERIALS AND METHOD

Study was carried out at Gajah Mungkur Reservoir, Wono Girl District , Centre Java on February 2010 and July 2010. Measurements of environmental parameters were conducted at 6 station; station 1 (middle-I), station 2 (inlet of Wiroko river), station 3 (middle-II), station 4 (floating cage culture), station 5 (inlet of Keduang), and station 6 (outlet/dam) (Figure 1).

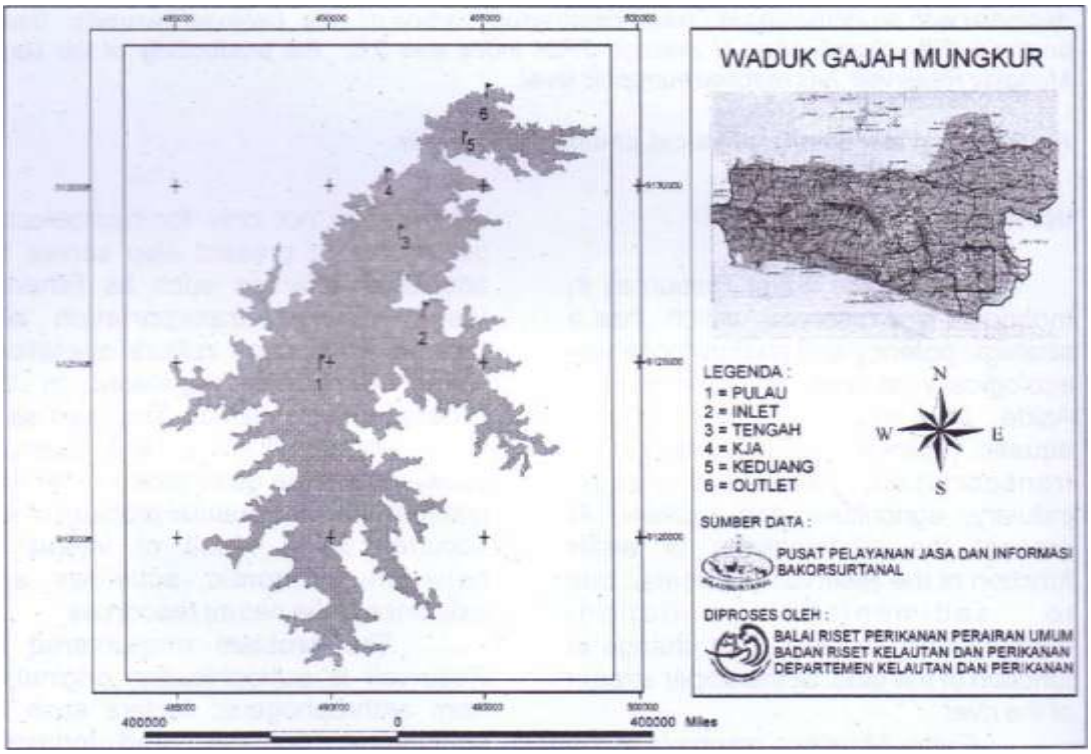

Figure 1. Map of Research Location at Gajah Mungkur Reservoir

Monthly observation for measurements of environmental parameters included temperature, TDS, TSS, turbidity, dissolved oxygen (DO), total-P, total-N, NO_3-N, PO_4-P and chlorophyll-a each at a depth of 0, 3, 5, and bottom (Table 1).

Table 1. Parameters and methods for physical and chemical of aquatic environment

PARAMETERS	UNIT	MATERIAL AND METHODS
1. P-Total	mg/l	Vanadate molibdate method Spectrophotometric
2. N-Total	mg/l	Vanadate molibdate method Spectrophotometric
3. Chlorophyle - a	mg/l	Spectra photometric
4. Temperatur	oC	Insitu. Termometer
5. Transparancy	Cm	Insitu. Sechi disk
6. Conductivity	µS/Cm	Insitu. Conductivity meter
7. pH	pH Unit	Insitu. pH universal indicator
8. CO2	mg/L	Insitu,Winkler metods titrimetri NaOH as a titrant
9. Oksigen	mg/L	Do meter
10. BOD	mg/L	Insitu, Winkler method, trtrimetn thiosulfat as a titrant

Sources : APHA (1986)

The trophic state of the waters analyzed with following TRIX model (Vollenweider *et al.* 1998 *after* EEA, 2001). The index derived from the four chosen variables (chlorophyll-a, oxygen saturation, total nitrogen and total phosphorous) is:

$$Xc = k/n \sum [(M-L)/(U-L)]$$

where:
n = number of the variables,
M = measured value of the variable.
U = upper limit,
L = lower limit.
Or :

$$TRIX = [k((Logrlif - LogL))1 ; y (LogU - LogL)$$

RESULTS AND DISCUSSION

Environmental Quality of Gajah Mungkur Reservoir

The surrounding area of Gajah Mungkur Reservoir is mountainous and hilly, while the river has many tributaries at this location. This makes the shape of Gajah Mungkur Reservoir very irregular or dendritic, with many extended bays.

The Reservoir area was densely populated (710.000 peoples) by farmer, fishermen, seller, civil servant. The land used of the catchment areas are faced with high pressured by sedimentation since over 70 % of the land used consists of the yard around a dwelling and the unirrigated filed, and the forest 13,2 % only (Table 2). The growth of farmer population has caused the decrease of landholding and this condition forced the to extend their agricultural land by forest clearing and utilize marginal lands. As a consequence, there is a prevailing problem of floods accompanied by accelerated soil erosion in rainy seasons. Sedimentation rate of Gajah Mungkur Reservoir was 7000.000 m^3/yea r (Jasa Tirta, 2008).

Table 2. The land used of the catchment areas of Gajah Mungkur Reservoir.

Land Used	Square (Km2)	(%)
The Forest	166	13,2
The unirrigated filed/ dryland	506	40,2
The yard around a dwelling	362	28,7
The Irrigation	226	17,9

Sources : Ministry of Public Works, Republic of Indonesia

Table 3. Water Quality at Gajah Mungkur Reservoir on February 2009

Station	Date	Parameters	Depth (m)			
			0	3	5	Base
Floating cage Cuitere area	27/5/2009	pH	7.5	7.5	7.5	
GPS:		Temperature (°C)	30	30	30	29.5
S 07°52'26.3"		Disolved 0_2 (mg/L)	6.63	6.14	5.74	0.0
E : 110°54'33.9"		0_2 saturation (%)	87.65	81.24	75.89	0.00
		CO_2 (mg/L)	0	0.88	1.76	13.2
		BOD (mg/L)	0,40	0.24	0.24	
		Klorofil-a (pg/L)	15.47	357	5.95	
		T-Alkalinity (mg/L)	67	79	53	
		DHL (pS)	230	250	250	
		TDS {ppm)	120	130	120	
		Turbidity (NTU)	1.56	2.71	1.94	
		TN (ppm)	4.25	6.99	4.25	
		N-NO_3 (pg/L)	0.80	0.67	0.85	
		P-PO_4 (pg/L)	2.23	3.07	2.23	
		TP (pg/L)	36.42	13.34	18.93	
		TSS (mg/L)	9	0	0	
		Transparancy (cm)		137.5		
		Depth area (m)		14.23		
Outlet	27/5/2009	pH	7.5	7.5		
GPS:		Temperature (°C)	32	29.5		29.5
S: 07°50'38.1"		Disolved 0_2 (mg/L)	7.11	6.95		6.38
E: 110°55'32.5"		0_2 saturation (%)	97.41	91.92		84.44
		CO_2 (mg/L)	0	0		0
		BOD (mg/L)	1.37	0.16		
		Klorofil-a (pg/L)	10.71	14.28		
		T-Alkalinrtas (mg/L)	66	58		
		DHL (pS)	230	220		
		TDS (ppm)	120	110		
		Turbidity (NTU)	5.98	14.59		
		TN (ppm)	5.62	4.93		

Table 3 (Continued)

Station	Date	Parameters	Depth (m)			
			0	3	5	Base
		$N\text{-}NO_3$ (pg/L)	0.58	0.26		
		$P\text{-}PO_4$ (pg/L)	3.90	3.90		
		TP (pg/L)	28.31	34.47		
		TSS (mg/L)	33	37		
		Transparancy (cm)		38.5		
		Depth area (m)		5.03		
Center 1	28/5/2009	pH	8	7.5	7.5	
GPS :		Temperature (°C)	30.6	30	29	29.0
S : 07°52' 10.9"		Disolved 0_2 (mg/L)	7.60	6.06	5.66	4.28
E : 110°54' 28.9"		O2 saturation (%)	102.23	80.17	73.56	55.69
		CO_2 (mg/L)	0	0	1.76	5.28
		BOD (mg/L)	1.13	0.32	1.78	
		Chiorofil-a (pg/L)	9.53	22.61	16.66	
		T-Alkalinity (mg/L)	78	88	61	
		DHL (pS)	250	240	240	
		TDS (ppm)	130	120	120	
		Turbidity (NTU)	7.24	2.14	2.97	0
		TN (ppm)	2.88	6.3	4.25	
		$N\text{-}NO_3$ (1.1g/1-)	0.35	0.49	0.49	
		$P\text{-}PO_4$ (pg/L)	2.23	3.07	3.90	
		TP (pg/L)	31.39	26.11	47.2	
		TSS (mg/L)	11	2		4
		Transparancy (cm)		129.5		
		Depth area (m)		17.16		
Inlet S. Wiroko	28/5/2009	pH	8	7.5		7.5
GPS Position		Temperature (°C)	30.5	29	29	29
S: 07°53'98.2"		Disolved 0_2 (mg/L)	7.19	5.98	5.01	4.53
E:$110^0$54·96.4"		O2 saturation (%)	96.80	77.76	65.15	58.85
		CO_2 (mg/L)	0	0	2.64	3.52
		BOD (mg/L)	0.57	0.16	-0.16	
		Chiorofil-a (pg/L)	11.9 7.24	8.33	13.09	
		T-Alkalinity (mg/L)	54	81	52	
		DHL (pS)	250	220	220	
		TDS (ppm)	120	120	120	
		Turbidity (NTU)	44.8	24.5	20.2	
		TN (ppm)	2.88	2.19	4.2	
		$N\text{-}NO_3$ (1.1g/1-)	0.67	0.58	0.40	
		$P\text{-}PO_4$ (pg/L)	4.73	4.73	3.07	
		TP (pg/L)	30.4 7.24	23.83	32.48	
		TSS (mg/L)	18	11	51	
		Transparancy (cm)		62.5		
		Depth area (m)		7.50		

Table 4. Water Quality at Gajah Mungkur Reservoir on July-August 2009

Station	Date	Parameters	DEPH (m)			
			0	3	5	Bottom
Cage Culture of Aquafarm	01/08/2009	pH	8	7.5	7.5	
GPS:		Temperature (°C)	28.7	27	27	
S : 07°52'185"		Disolved 0_2 (mg/L)	6.71	4.04	3.88	3.7
E : 110°54'25.5"		0_2 saturation (%)	87.22	50.70	48.67	46.64
		CO_2 (mg/L)	0	1.76	3.52	3 52
		Chlorofil-a (pg/L)	11.9	5.95	35.7	
		T-Alkalinity (mg/L)	84	69	70	
		DHL (pS)	280	270	270	
		TDS (ppm)	140	140	130	
		Turbidity (NTU)	5.98	8.56	8.98	
		TN (ppm)	0.48	0.65	0.48	
		N-NO_3 (pglL)	0.27	0.28	0.26	
		P-PO_4 (pg/L)	0.55	0.73	8.00	
		TP (pg/L)	30.43	18.93	64.57	
		TSS (mg/L)	8	10	12	
		Transparancy (cm)		75		
		Depth area (m)		15		
Outlet	01/08/2009	pH				8
GPS:		Temperature (°C)	27.4			26.5
S: 07°50'452"		Disolved 0_2 (mg/L)	6.71			6.14
E: 110°55'620"		0_2 saturation (%)	85.66			70.97
		CO_2 (mg/L)	0			C
		BOD (mg/L)				
		Chlorofil-a (pg/L)	15.47			35.7
		T-Alkalinity (mg/L)	55			61
		DHL (pS)	270			26C
		TDS (ppm)	130			
		Turbidity (NTU)	7.48			47.6
		TN (ppm)	0.83			1.18
		N-NO_3 (pg/L)	0.27			0.26
		P-PO_4 (pg/L)	1.45			3.82
		TP (pg/L)	36.42			64.57
		TSS (mg/L)	9			9.9
		Transparancy (cm)		75		
		Depth area (m)		3.50		

Table 4. (Continued)

Station	Date	Parameters	DEPH (m)			
			0	3	5	Bottom
Middle II						
GPS	29/07/2009	pH	8	8		
S : 7°54' 9.86"		Temperature (°C)	28	26		
E : 110°53' 26.7"		Disolved 0_2 (mg/L)	6.63	6.14		
		0_2 saturation (%)	84.63	75.73		
		CO_2 (mg/L)	0	0		
		BOD (mg/L)	2.31	0.54		
		Chlorofil-a (pg/L)	23.8	33.32		
		T-Alkalinity (mg/L)	65	65		
		DHL (pS)	270	240		
		TDS (ppm)	130	120		
		Turbidity (NTU)	6.39	8.82		
		TN (ppm)	0.48	0.48		
		N-NO_3 (pglL)	0.24	0.22		
		P-PO_4 (pg/L)	6.55	5.09		
		TP (pg/L)	48.91	61.59		
		TSS (mg/L)	8	2		
		Transparancy (cm)		76		
		Depth area (m)		4.35		
Inlet S. Keduang	01/08/2009	pH	8.5			8
GPS:		Temperature (°C)	31.4			27
S: 07°50' 8.99"		Disolved 0_2 (mg/L)	7.11			5.86
E: 110°56' 0.71"		0_2 saturation (%)	95.71			70.97
		CO_2 (mg/L)	0			1.76
		BOD (mg/L)				
		Chlorofil-a (µg/L)	29.75			5.95
		T-Alkalinity (mg/L)	72			56
		DHL (pS)	250			290
		TDS (ppm)	140			150
		Turbidity (NTU)	10.19			68.9
		TN (ppm)	0.65			2.23
		N-NO_3 (pg/L)	0.26			0.33
		P-PO_4 (pg/L)	1.27			2.55
		TP (pg/L)	57			18.93
		TSS (mg/L)	26			76
		Transparancy (cm)		70		
		Depth area (m)		4		

Temperature

The water temperature of Gajah Mungkur Reservoir during the observation was between 26° - 32 °C and the water tended to decrease with an increasing in water depth.The temperature distribution on water depth had an oligomictic pattern by a nonsignificant different among depth (Table 3, Table 4, Figure 2 and Figure 3).

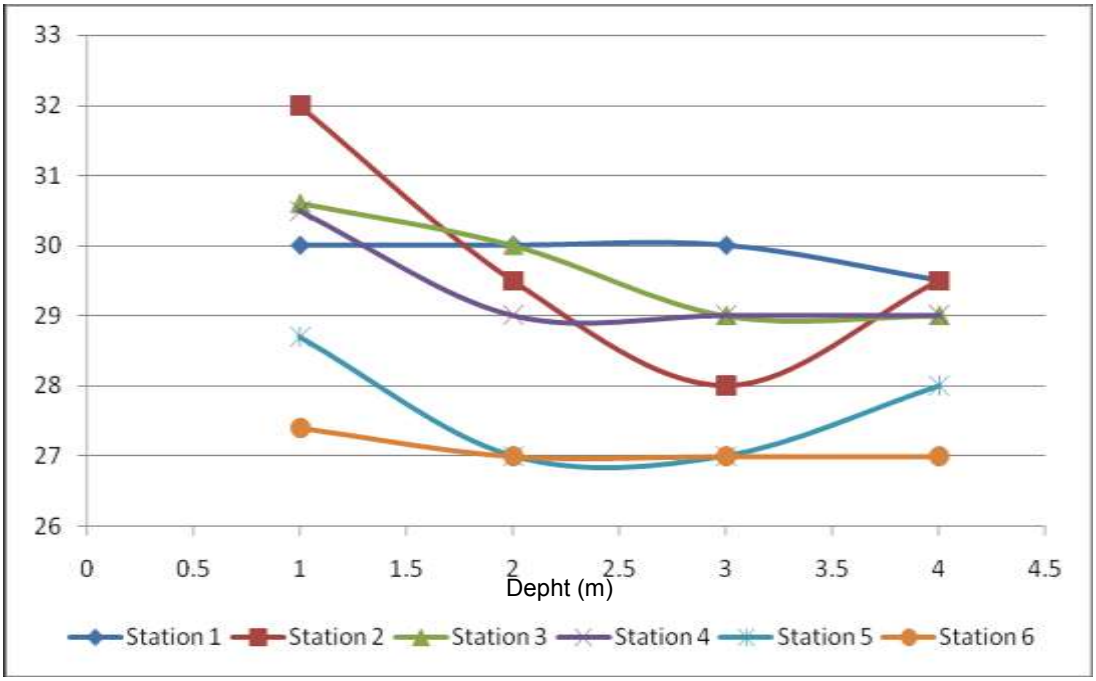

Figure 2. Temperature of Gajah Mungkur Reservoir in February 2009

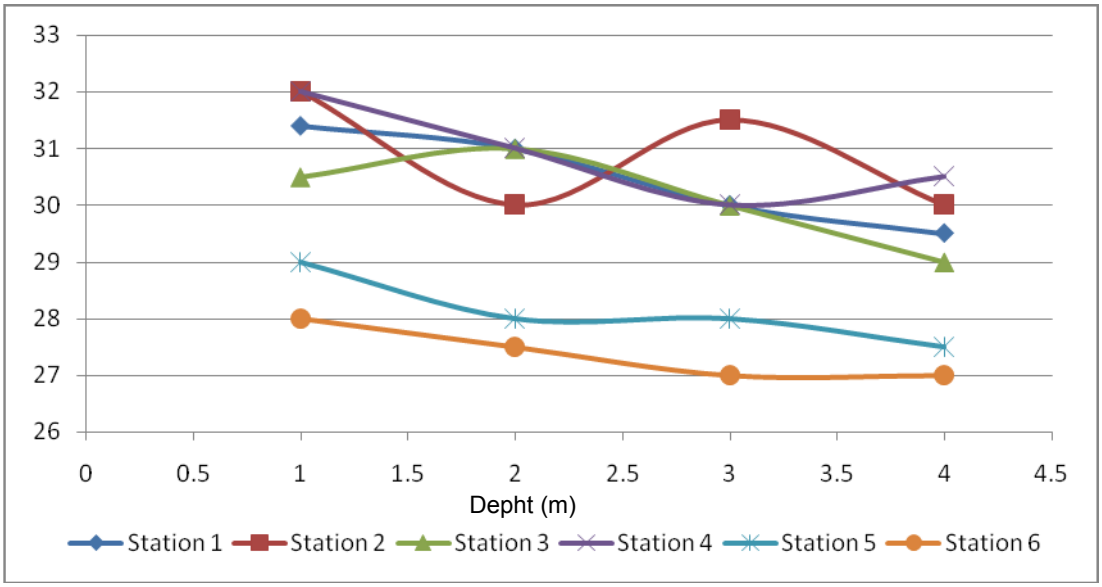

Figure 3. Temperature of Gajah Mungkur Reservoir in August 2009

Transparancy

Transparancy tended to be significantly high in rainy season (February) than that in dry season (July-August), (Table 4).

The decreased values in dry season was due to the lowest water level. The transparency value also significantly increased from the shallow area (near inlet or off shore area) to the deep area (middle area). The decreasing of the transparency values of the inlet area was due to accumulation of inorganic particles originated from the erosion of the watershed area and from

the reservation of sediments at the lose of the reservoir.

TSS and TDS

Concentration of TSS tended to be higher in rainy season (February) than that in dry season (August (Table 4)). It may relate to eroded material washed out by the rain fall. TSS value was higher in the inlet of Keduang than that in other stations indicating highest erosion and sedimentation.

Unlike TSS, TDS content tended to be significantly lower in rainy season (February) than that in dry season (July-August) (Table 4),.. High TDS content in dry season may related concentrating of the ion as *a* result of decreasing in water level. The TDS load can be caused by the antrophogenic substances from domestic or fish cage culture in reservoir (Effendi, 2000).

Dissolved Oxygen Content

Dissolved oxygen content (DO). an indicator of environmental sensitively of aquatic life, mainly fish, derived from photosynthesis and also from physical processes, such as current and temperature. Dissolved oxygen content in all stations from the surface layer up to 5 m depth were in the tolerable range (> 3 mg/l) for fish life. At the bottomof the reservoir, the dissolved oxygen ranged from 0 to 6 mg/l, and it tended to decrease with an increasing of water depth (Table 3, Table 4, Figure 4 and 5)

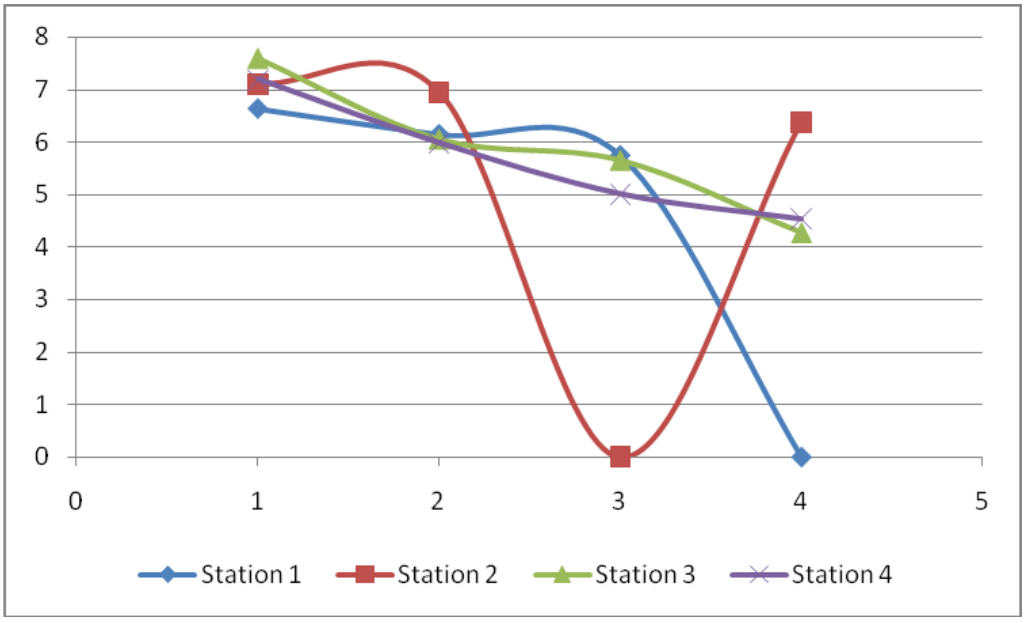

Figure 4. Dissolved oxygen of Gajah Mungkur Reservoir in May, 2009

N/P Ratio (pg/L) and Chlorophyll a

Total phosphor in all stations were in the range of 18.9 - 115.4 (pg/L) and with average value of 48.2 (pg/L); while the range of total N were 0.48 - 13.87 mg/l with average value was 4.38 mg/l. The ratio of total N : total P (4.38 mg/1: 0.0482 mg/l) at Gajah Mungkur Reservoir was 98.8: 1, showed that the total P as a limiting factors, where N/P ratio > 16:1 (Mason 1993 in Effendi 2000). Based on the fertility classification using average total P and total N as parameters,Gajah Mungkur Reservoir was classified as eutrophic water (UNEP-IETC-ILEC-2001).

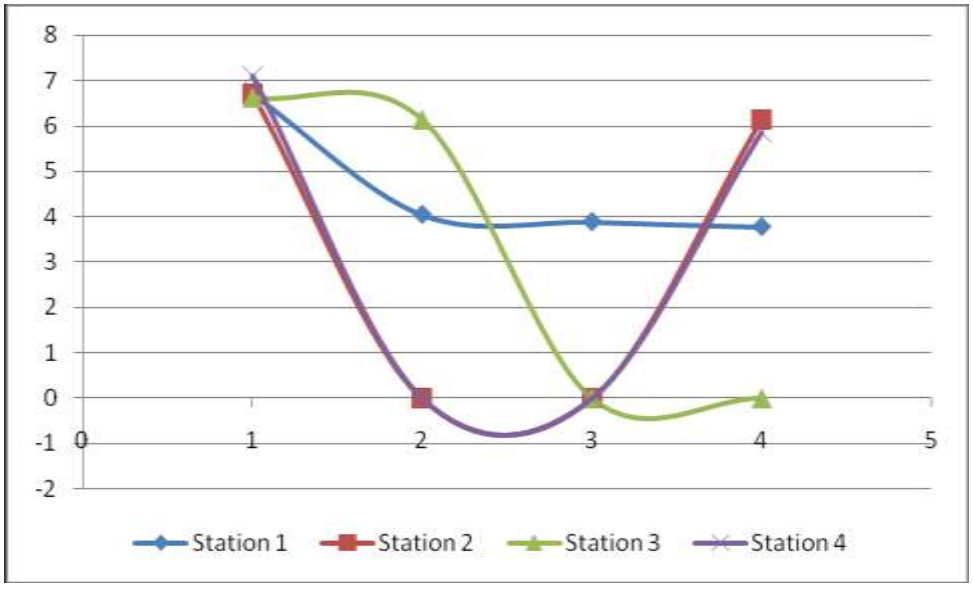

Figure 5. Dissolved oxygen of Gajah Mungkur Reservoir in August 2009.

Based on the classification of OECF (1986) in EEA (2001) using chlorophyll a (Table 4) as the indicator, Gajah Mungkur Reservoir has also reached eutrophic-level.

TRIX Index

The trophic state depends on the availability of nitrogen and phosphorus for the primary production, which in terms determines the phytoplankton biomass and oxygen saturation. The TRIX values at station 1(middle-I). 2(inlet Wiroko), 4(Cage culture), 5(outlet), and (inlet Keduang) was 4.9,5.8, 5.4, 5.9,.7,and 6 respectively. Based on the fertility classification of TRIX the productivity of the Gajah Mungkur Reservoir has reached eutrophic level.

CONCLUSION

- The catchment areas of Gajah Mungkur Reservoir were suffered from erosion and sedimentation problem.
- Based on the fertility classification of TRIX Index, NIP ratio and Chlorophyll a content, Gajah Mungkur Reservoir has reached eutrophic level

REFERENCES

APHA, 1986. Standard methods for the examinations of water and wastewater. APHA Washington DC. p. 986

Departemen Pekerjaan Umum Dirjen Pengairan,1992, Rencana Pengelolaan Lingkungan Waduk Wonogiri, Lenibaga Penelitian UNDIP, Semarang. P. 64

Effendi H 2003. Telaah Kualitas Air, Jurusan MSP, Fak.Penkanan dan Kelautan IPBBogor. P. 259

European Environmental Agency. 2001. Eutrophication in Europe's coastal waters.Topic report. 7/2001.p. 115.

Garno,Y.S.2001, Status dan karakteristik pencemaran di Waduk Kaskade Citarum. Jumal Teknologi Lingkungan, Dit. Teknologi Lingkungan, Deputi Bidang Teknologi Informasi, Energi, Material dan Lingkungan, BPPT. Jakarta. Vol.2, No. 2, Mei 2001. ISSN 1411-318X

Jasa Tirta, 2008.Pekerjaan Pengukuran Echo Sounding Waduk Wonogiri. Perum Jasa Tirta I. Surakarta.p136

UNEP-IETC-ILEC.2001. Lakes and reservoirs. Water quality: The impact of utrophication. Vol.3, ISBN4-906356-31-1.

DISCUSSION DURING CONFERENCE

Question from: Mr. Gordon Douglas Haffner

1. Does an eutroph reservoir still well Advised to floating nets aquaculture?

Answer :

An eutroph reservoir well used for floating nets with consideration of proportional feeding and water flow through the outlet is maintained so that freshness of water with the turn of the new water to make fish in floating nets do not stress.