

Article

Multivariate Statistical Analysis of Water Quality and Trophic State in an Artificial Dam Reservoir

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Supplementary Materials

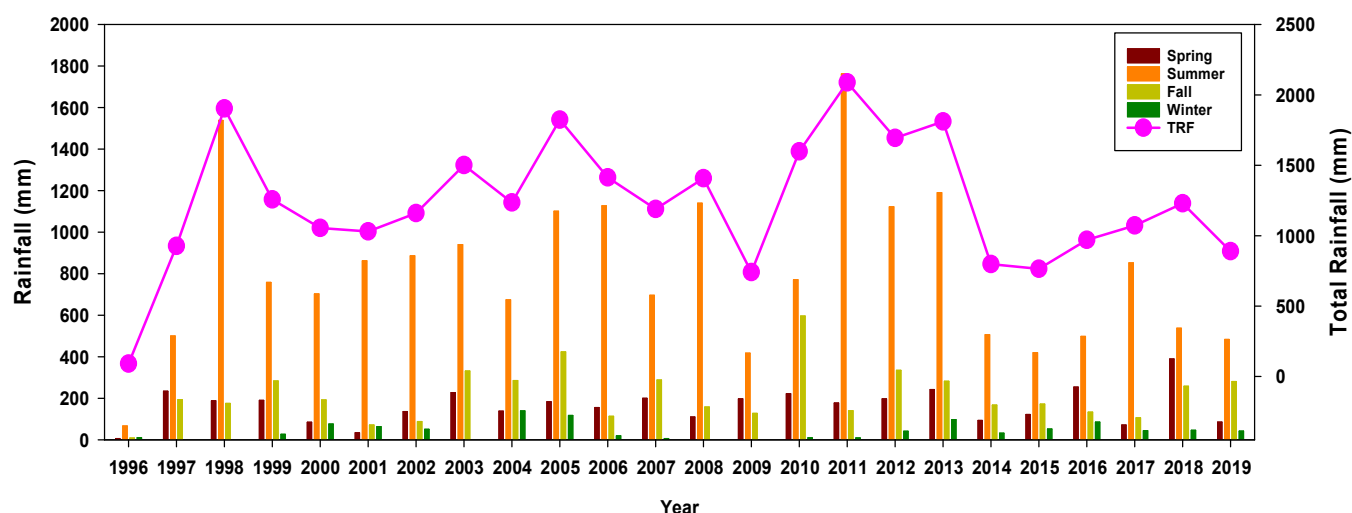


Figure S1. Seasonal and Total rainfall pattern of Paldang watershed. (Spring: March–May, Summer: June–August, Fall: September–November, Winter: December–February, and TRF: Total Rainfall)

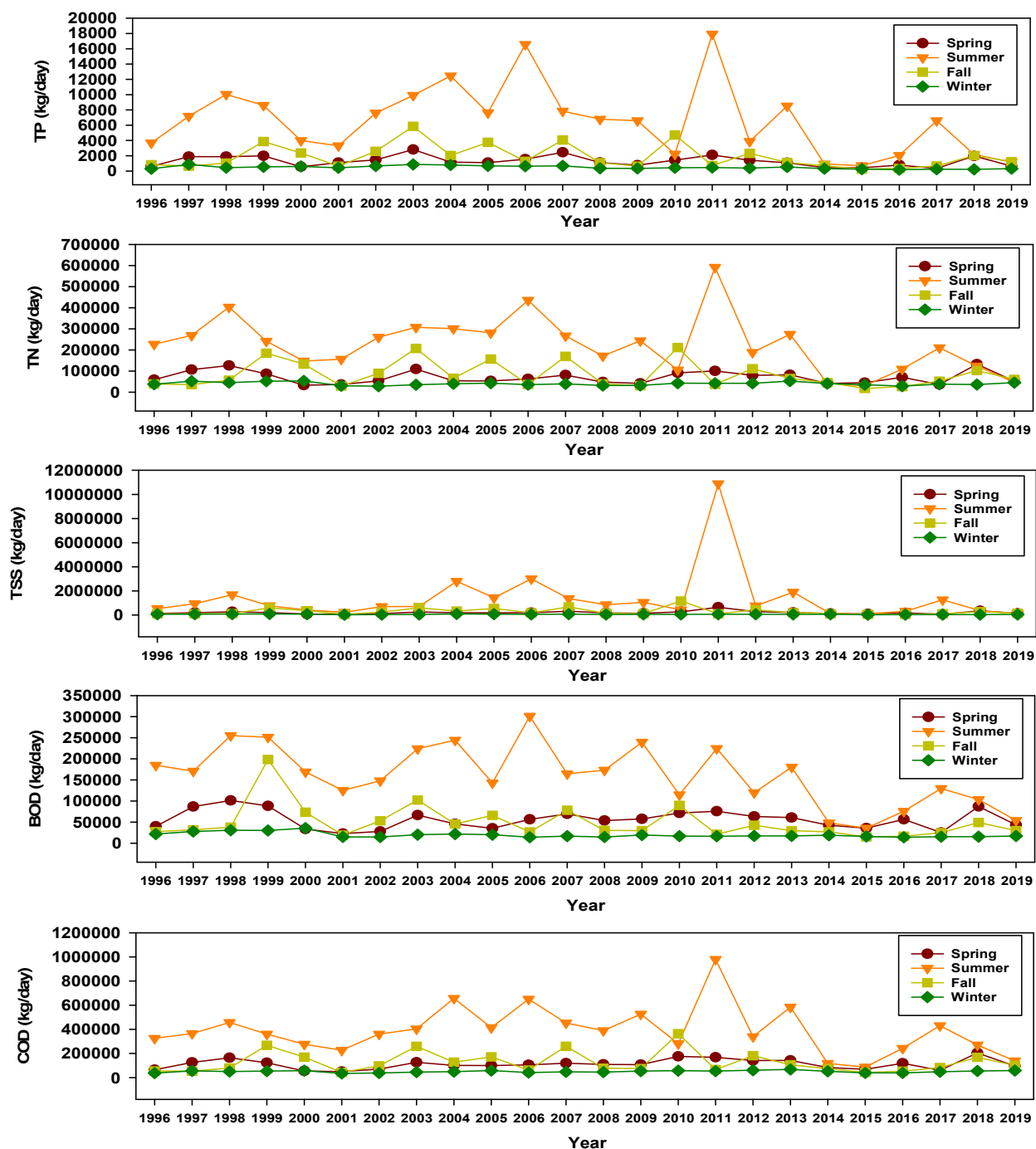


Figure S2. Loading Data of TP, TN, TSS, BOD, and COD in the Paldang Reservoir. (TP—total phosphorus, TN—total nitrogen, TSS—total suspended solids, BOD—biological oxygen demand, COD—chemical oxygen demand, Spring: March–May, Summer: June–August, Fall: September–November, Winter: December–February)

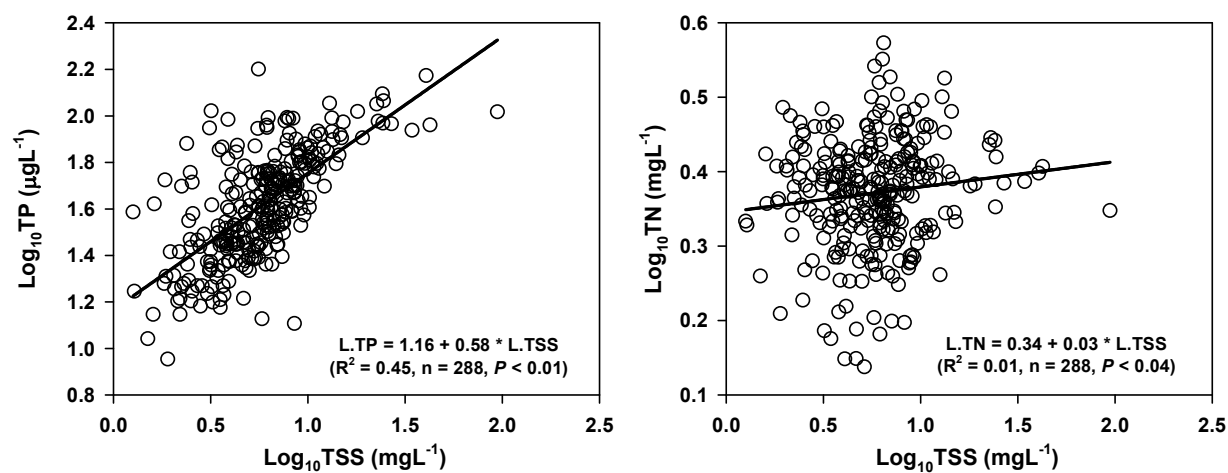


Figure S3. Empirical relations among TSS, TP, and TN. (TP—total phosphorus, TN—total nitrogen, TSS—total suspended solids)

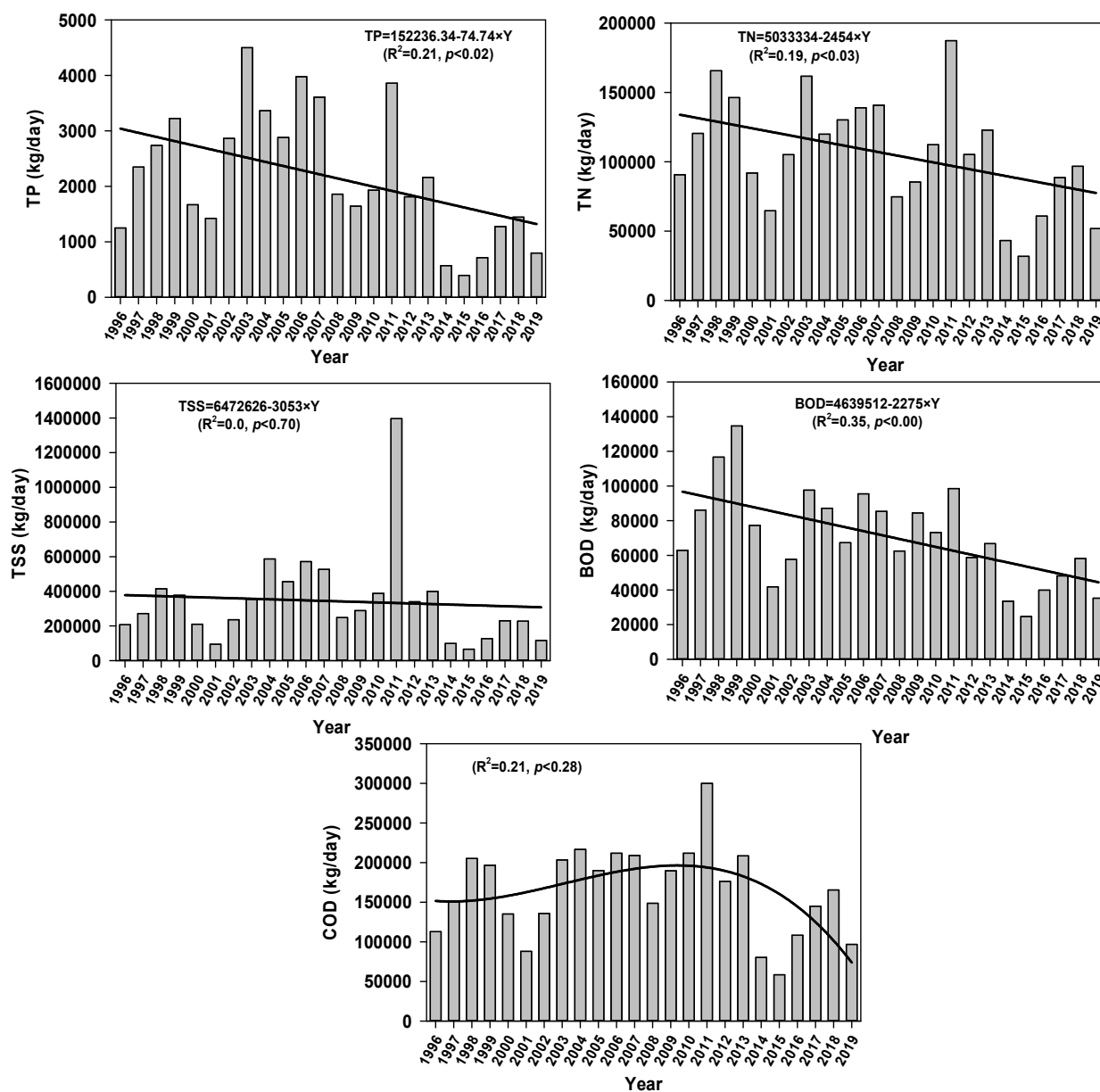


Figure S4. Yearly loading Data of TP, TN, TSS, BOD, COD. (TP—total phosphorus, TN—total nitrogen, TSS—total suspended solids, BOD—biological oxygen demand, COD—chemical oxygen demand)

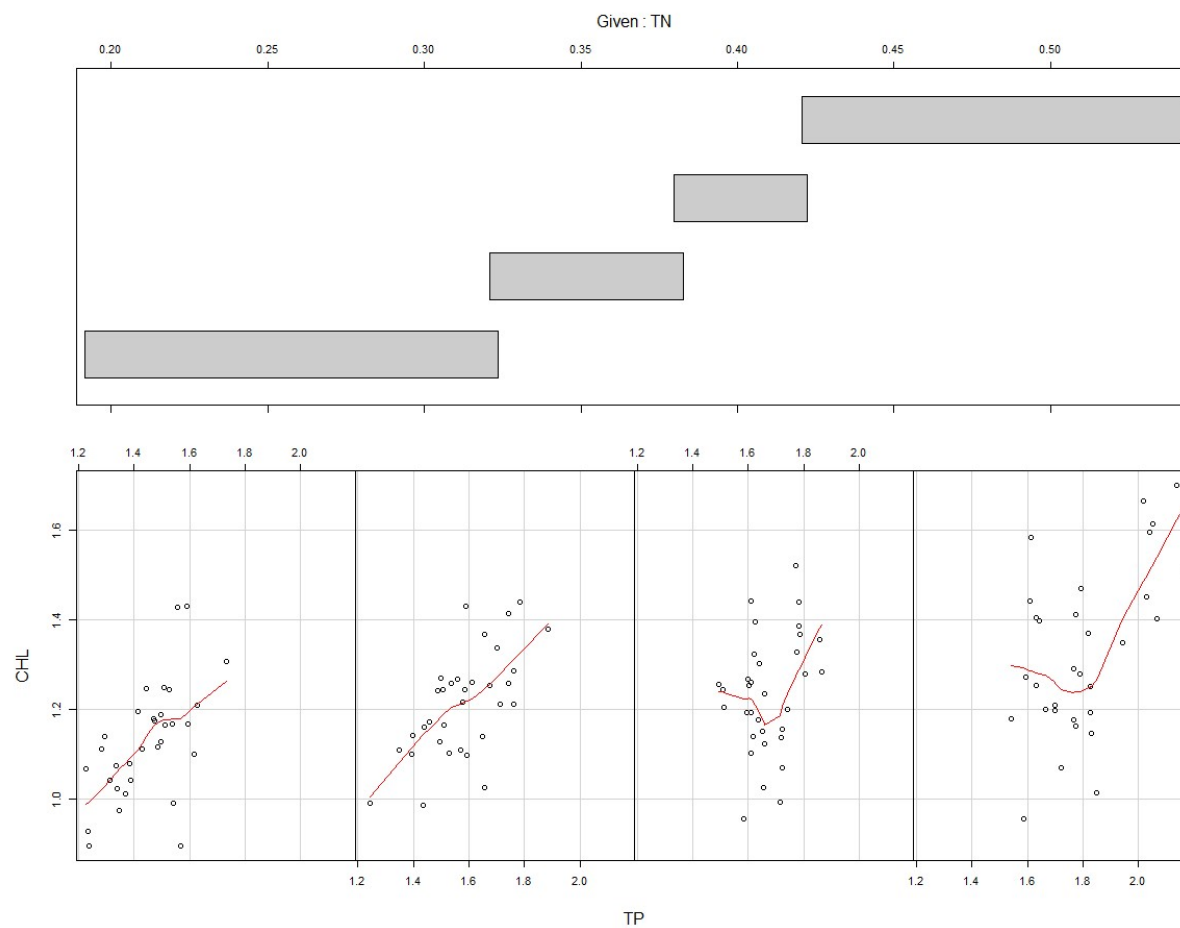


Figure S5. The relationship between CHL-a and TP is plotted conditional on the range of TN. (TP—total phosphorus, TN—total nitrogen, CHL-a—Chlorophyll-a)

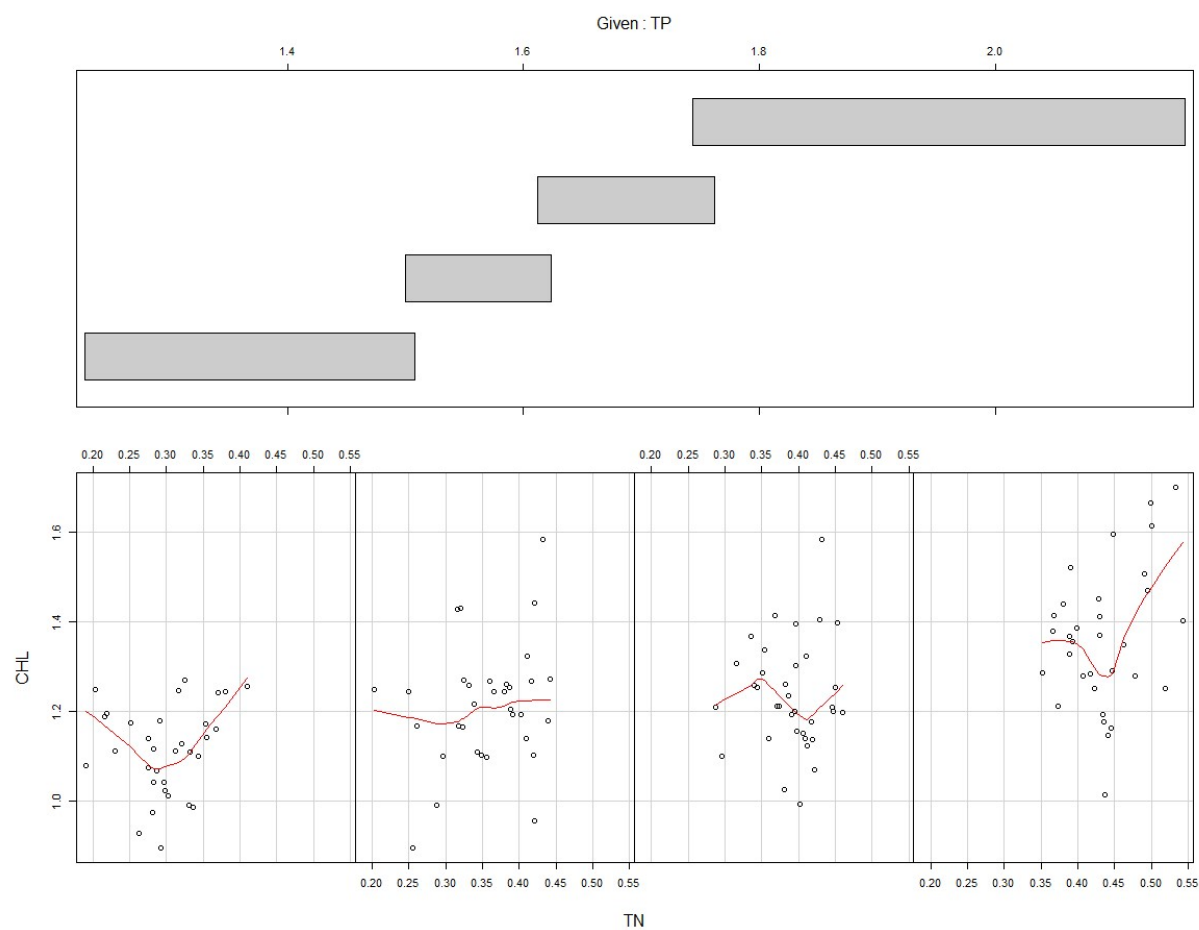


Figure S6. The relationship between CHL-a and TN is plotted conditional on the range of TP. (TP—total phosphorus, TN—total nitrogen, CHL-a—Chlorophyll-a)

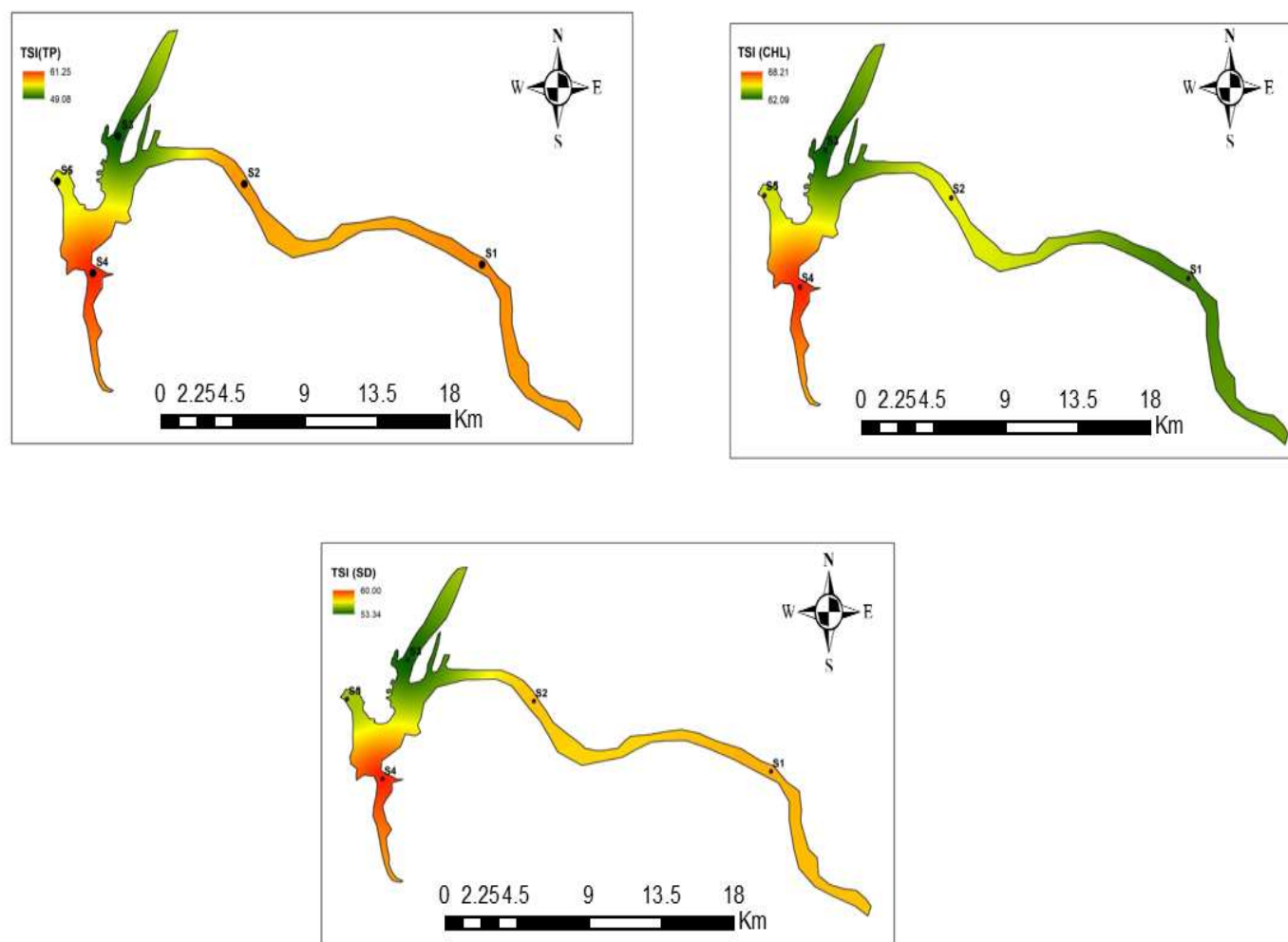


Figure S7. Trophic state index of Paldang Reservoir at five different sites

Table S1. Water quality classes of Paldang Reservoir based on sites and seasons according to the Korean Ministry of Environment water quality standards for reservoirs and lakes. (pH—hydrogen ion concentration, DO—dissolved oxygen, COD—chemical oxygen demand, TSS—total suspended solids, TN—total nitrogen, TP—total phosphorus, CHL-a—chlorophyll-a, TCB—total coliform bacteria, Ia: very good (high quality water), Ib: good (high quality water), II: somewhat good (lightly contaminated water), III: average (contaminated water), IV: somewhat poor (contaminated water), V: poor (highly contaminated water), VI: very poor (highly contaminated water))

Variables	Water Quality Classes							Mean Values at Sites (Class)					Mean Values at Seasons (Class)			
	Ia	Ib	II	III	IV	V	VI	S1	S2	S3	S4	S5	Spring	Summer	Fall	Winter
pH	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.0–8.5	6.0–8.5		8.19 (Ia)	8.27 (Ia)	8.02 (Ia)	8.22 (Ia)	8.14 (Ia)	8.41 (Ia)	8.13 (Ia)	8.04 (Ia)	8.09 (Ia)
COD (mgL ⁻¹)	<2	<3	<4	<5	<8	<10	>10	3.71 (II)	3.82 (II)	3.23 (II)	4.65 (III)	3.5 (II)	4.2 (III)	4.17 (III)	3.63 (II)	3.11 (II)
TSS (mgL ⁻¹)	<1	<5	<5	<15	<15			8.22 (III)	7.8 (III)	4.36 (II)	8.5 (III)	6.74 (III)	7.22 (III)	10.75 (III)	7.07 (III)	3.44 (II)
DO (mgL ⁻¹)	>7.5	>5.0	>5.0	>5.0	>2	>2	<2	11.18 (Ia)	11.28 (Ia)	11.04 (Ia)	11.11 (Ia)	10.79 (Ia)	12.16 (Ia)	9.09 (Ia)	9.9 (Ia)	13.18 (Ia)
TP (µgL ⁻¹)	<10	<20	<30	<50	<100	<150	>150	50.38 (IV)	49.45 (III)	26.35 (II)	69.99 (IV)	38.61 (III)	47.83 (III)	61.76 (IV)	48.46 (III)	29.78 (II)
TN (mgL ⁻¹)	<0.2	<0.3	<0.4	<0.6	<1.0	<1.5	>1.5	2.56 (VI)	2.51 (VI)	1.88 (VI)	2.79 (VI)	2.16 (VI)	2.57 (VI)	2.24 (VI)	2.25 (VI)	2.46 (VI)
CHL-a (µgL ⁻¹)	<5	<9	<14	<20	<35	<70	>70	17.46 (III)	18.64 (III)	12.46 (II)	26.24 (IV)	15.32 (III)	24.33 (IV)	19.56 (III)	16.14 (III)	12.06 (III)
TCB (MPN 100ml ⁻¹)	<50	<500	<1000	<5000				2225.12 (III)	2357.05 (III)	633.2 (II)	1701.32 (III)	738.67 (II)	395.51 (Ib)	3421.38 (III)	1898.88 (III)	400.69 (Ib)

Table S2. Pearson correlation analysis of water quality parameters. (units mgL^{-1} , except pH, WT ($^{\circ}\text{C}$), EC (μScm^{-1}), TP (μgL^{-1}), CHL-a (μgL^{-1}), SD (m) and TCB (MPNML^{-100}). pH—hydrogen ion concentration, WT—water temperature, DO—dissolved oxygen, EC—electrical conductivity, BOD—biological oxygen demand, COD—chemical oxygen demand, TSS—total suspended solids, TN—total nitrogen, TP—total phosphorus, CHL-a—chlorophyll-a, SD—Secchi depth, TCB—total coliform bacteria

	pH	WT	DO	EC	BOD	COD	BOD/COD	TSS	TN	TP	TN:TP	CHL-a	SD	TCB
pH	1													
WT	0.30**	1												
DO	0.16	−0.09	1											
EC	−0.005	0.51**	0.006	1										
BOD	0.43**	0.49**	0.26**	0.40**	1									
COD	−0.14	0.28**	0.23**	0.59**	0.51**	1								
BOD/COD	0.62**	0.35**	0.07	0.02	0.72**	−0.19*	1							
TSS	−0.15	−0.38**	0.31**	0.15	0.11	0.37**	−0.16	1						
TN	0.21*	0.18*	−0.03	0.55**	0.58**	0.41**	0.36**	0.40**	1					
TP	0.26**	−0.03	0.02	0.20*	0.52**	0.36**	0.29**	0.47**	0.73**	1				
TN:TP	−0.20*	0.16	−0.01	−0.12	−0.24**	−0.28**	−0.02	−0.41**	−0.39**	−0.66**	1			
CHL-a	0.45**	0.24**	0.05	0.27**	0.62**	0.40**	0.41**	0.15	0.53**	0.70**	−0.49**	1		
SD (m)	−0.31**	0.08	−0.23*	−0.18*	−0.49**	−0.29**	−0.36**	−0.48**	−0.62**	−0.64**	0.58**	−0.59**	1	
TCB	−0.06	−0.12	0.10	0.02	0.08	0.06	0.05	0.27**	0.33**	0.12	−0.10	−0.06	−0.24**	1

* = correlation is significant at the 0.05 level

** = correlation is significant at the 0.01 level

Table S3. Trophic state criteria based on TP, TN, CHL-a, and SD from Nurnberg (1996) for Paldang Reservoir. (TN—total nitrogen, TP—total phosphorus, CHL-a—chlorophyll-a, SD—Secchi depth, M: mesotrophic, E: eutrophic and H: Hypereutrophic)

Variables	Trophic State			Mean Values at Sites (Trophic State)					Mean Values at Season (Trophic State)			
	M	E	H	S1	S2	S3	S4	S5	Spring	Summer	Fall	Winter
TP (μgL^{-1})	≤ 10 –30	>30–100	>100	50.38 (E)	49.45 (E)	26.35 (M)	69.99 (E)	38.61 (E)	47.83 (E)	61.76 (E)	48.46 (E)	29.78 (M)
TN (mgL^{-1})	<1.5	>1.5–3	>3	2.56 (E)	2.51 (E)	1.88 (E)	2.79 (E)	2.16 (E)	2.57 (E)	2.24 (E)	2.25 (E)	2.46 (E)
CHL(μgL^{-1})	<9	>9–25	>25	17.46 (E)	18.64 (E)	12.46 (E)	26.24 (E)	15.32 (E)	24.33 (E)	19.56 (E)	16.14 (E)	12.06 (E)
SD (m)	>2<4	>1<2	≤ 1	1.31 (E)	1.32 (E)	1.73 (E)	1.1 (E)	1.49 (E)	1.3 (E)	1.21 (E)	1.38 (E)	1.67 (E)

Table S4. Thresholds of risk associated with potential exposure to cyanobacteria in Paldang Reservoir (adopted from WHO, 2015, LRE: lower risk of exposure, MRE: moderate risk of exposure and HRE: higher risk of exposure, TP—total phosphorus, CHL-a—chlorophyll-a, SD—Secchi depth)

Indicators	Thresholds			Mean Values at Sites					Mean Values at Season			
	LRE	MRE	HRE	S1	S2	S3	S4	S5	Spring	Summer	Fall	Winter
TP (μgL^{-1})	<10–25	25–100	>10	50.38 (MRE)	49.45 (MRE)	26.25 (MRE)	69.99 (MRE)	38.61 (MRE)	47.83 (MRE)	61.76 (MRE)	48.46 (MRE)	29.78 (MRE)
CHL(μgL^{-1})	<10	10–<50	>50	17.46 (MRE)	18.64 (MRE)	12.46 (MRE)	26.24 (MRE)	15.32 (MRE)	24.33 (MRE)	19.56 (MRE)	16.14 (MRE)	12.06 (MRE)
SD (m)	>2	<2–1	<1	1.31 (MRE)	1.32 (MRE)	1.73 (MRE)	1.1 (MRE)	1.49 (MRE)	1.3 (MRE)	1.21 (MRE)	1.38 (MRE)	1.67 (MRE)

Table S5. Classification matrix for discriminant analysis of spatial variations in water quality of the reservoirs

Sites	% Correct	Sites Assigned by DA				
Standard mode		S1	S2	S3	S4	S5
S1	100	17	8	0	0	0
S2	100	7	16	0	1	0
S3	100	0	0	24	0	1
S4	100	0	0	0	23	0
S5	100	0	0	0	0	23
Total		24	24	24	24	24
Stepwise mode						
S1	100	15	7	0	0	0
S2	100	9	17	0	1	0
S3	100	0	0	23	0	1
S4	100	0	0	0	23	0
S5	100	0	0	1	0	23
Total		24	24	24	24	24

Table S6. Classification matrix for discriminant analysis of seasonal variations in water quality of the reservoirs

Season	% Correct	Season Assigned by DA			
Standard Mode		Spring	Summer	Fall	Winter
Spring	100	53	0	3	1
Summer	100	1	63	22	0
Fall	100	11	9	45	0
Winter	100	7	0	2	71
Total		72	72	72	72
Stepwise mode					
Spring	100	51	0	5	1
Summer	100	0	65	22	0
Fall	100	12	7	42	0
Winter	100	9	0	3	71
Total		72	72	72	72