

Supplementary information

Water purifying capacity of natural riverine wetlands in relation to their ecological quality

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Figure S1: Nutrients (a, b, c, d, e, f), biochemical oxygen demand (g), and dissolved oxygen (h) gradient before joining, within and after passing through the wetland.

Supplementary result

Table S1. Site codes and their respective full name, and associated wetland

Site code	Site name	wetland
B1	Kochie stream	Boye
B2	Dololo stream	Boye
B3	University stream	Boye
B4	Awaitu river	Boye
B5	Within the wetland 1	Boye
B6	Within the wetland 2	Boye
B7	Within the wetland 3	Boye
B8	Outlet point	Boye
F1	Degoye stream 1	Fisho
F2	Degoye stream 2	Fisho
F3	Within the wetland 1	Fisho
F4	Within the wetland 2	Fisho
F5	Outlet point 1	Fisho
F6	Outlet point 2	Fisho
K1	Kitto stream 1	Kitto
K2	Kitto stream 2	Kitto
K3	Within the wetland 1	Kitto
K4	Within the wetland 2	Kitto
K5	Outlet point 1	Kitto
K6	Outlet point 2	Kitto

Table S2. Statistical summary for the spatiotemporal variation of Physicochemical parameters between wetland sites in the dry season based on Wilcoxon rank sum test. “P-corrected” is the p value after applying Bonferroni correction.

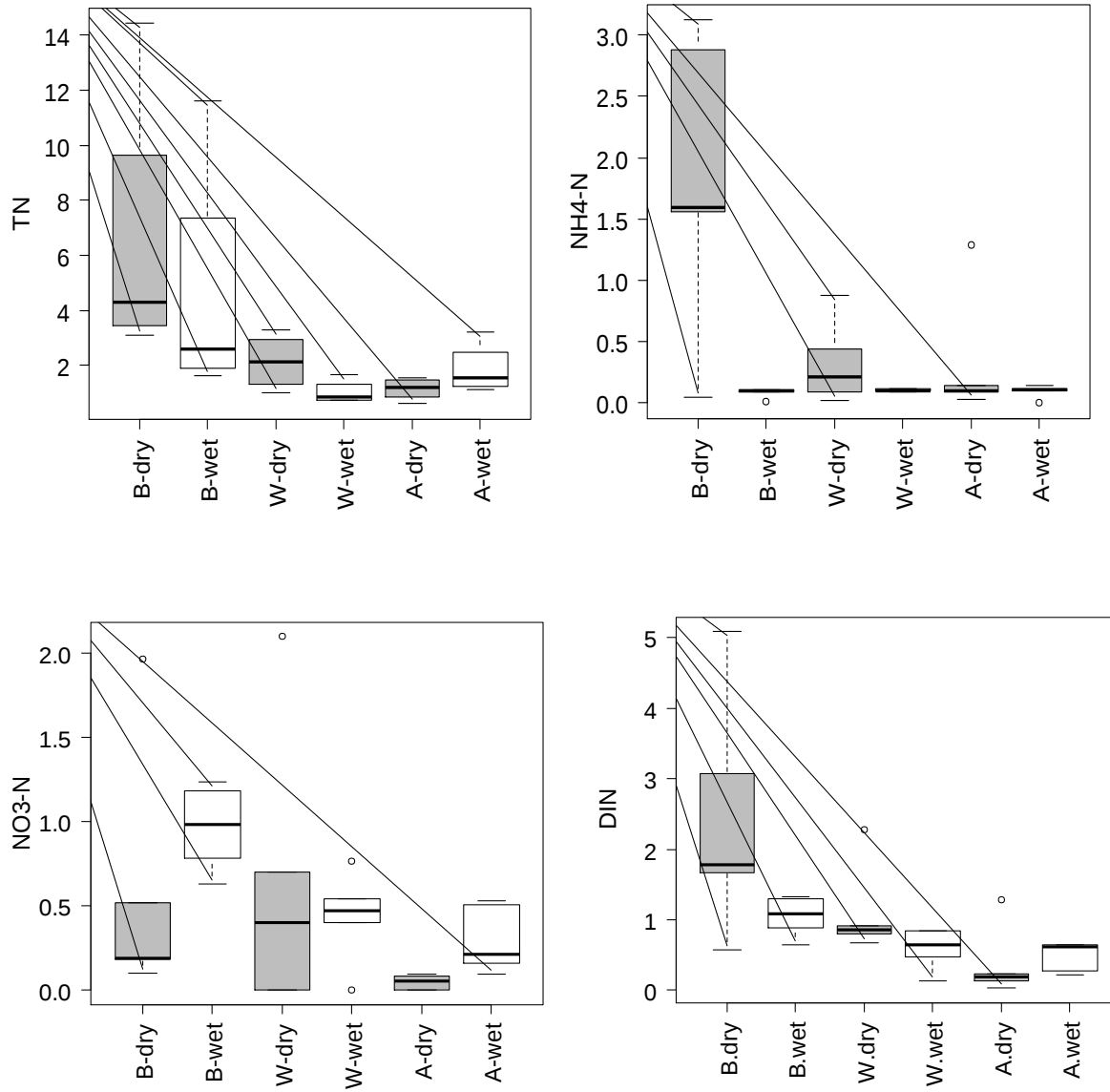
Boye ~ Fiso	W	P-value	P-corrected
TP	47	0.004	0.04
TN	40	0.004	0.04
PO4-P	47	0.003	0.03
NO3-N	24.5	0.1	1
NH4-N	47	0.001	0.01
BOD	26	0.84	8.4
DO	12	0.14	1.4
T°	32.5	0.3	3
Cl	7	0.03	0.3
TUR	30	0.49	4.9
pH	48	0.001	0.01
EC	46	0.003	0.03
Boye ~Kitto			
TP	43	0.001	0.01
TN	40	0.005	0.05

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PO ₄ -P	45	0.001	0.01
NO ₃ -N	32	0.33	3.3
NH ₄ -N	47	0.001	0.01
BOD	12	0.14	1.4
DO	33.5	0.24	2.4
T	38.5	0.07	0.7
Cl	12.5	0.15	1.5
TUR	38	0.08	0.8
EC	44	0.001	0.01
pH	40	0.04	0.4
Fisho~Kitto			
TP	8	0.13	1.3
TN	22	0.59	5.9
PO ₄ -N	12	0.29	2.9
NO ₃ -N	22	0.57	5.7
NH ₄ -N	14	0.59	5.9
BOD	5	0.004	0.04
DO	31	0.004	0.04

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T°	27.5	0.15	1.5
Cl	16	0.82	8.2
TUR	26	0.24	2.4
EC	95	0.20	2
pH	11	0.31	3.1



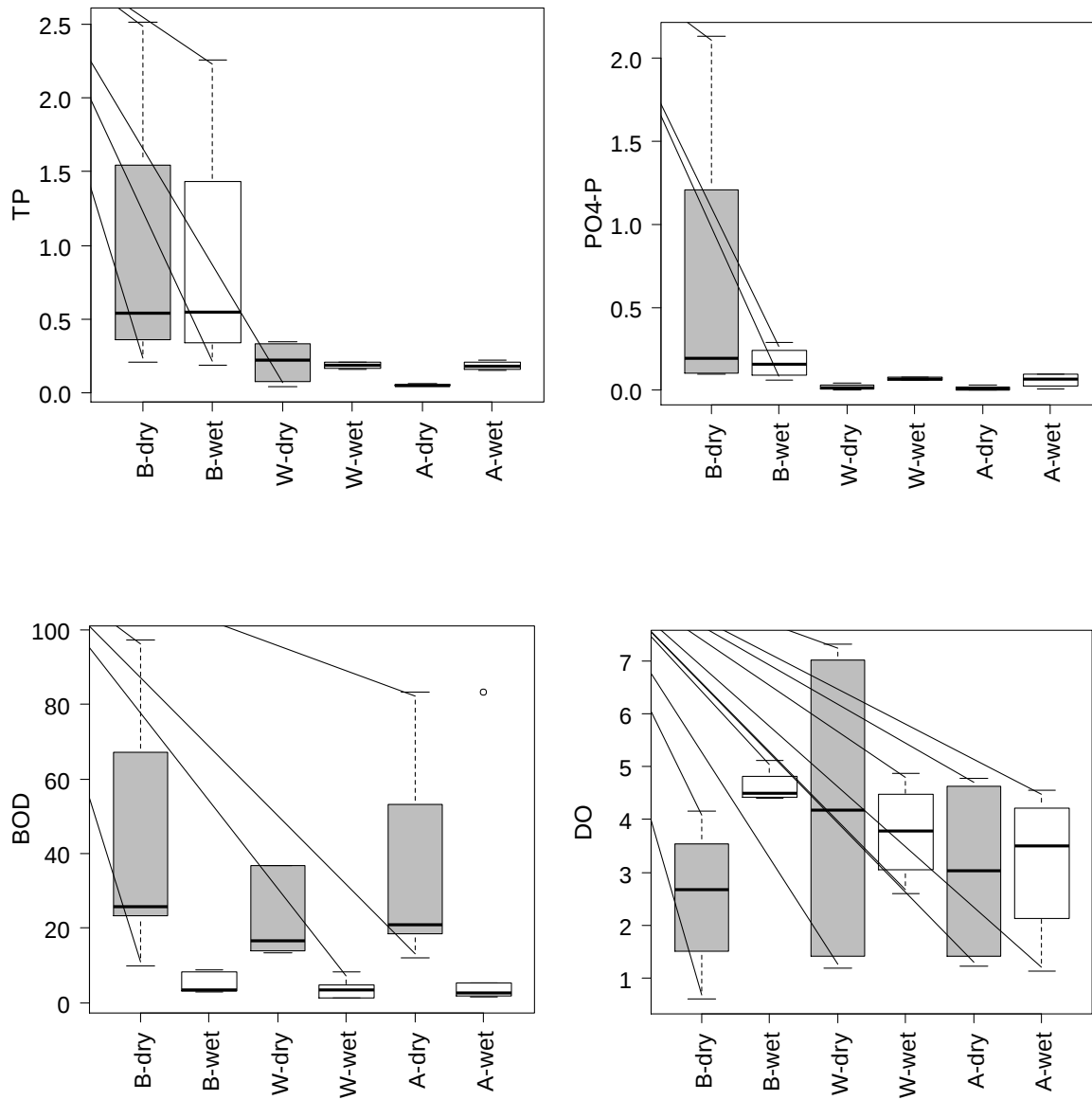


Figure S1. Nutrients, biochemical oxygen demand, and dissolved oxygen gradient among the different zones. Pooled value of the three wetlands; B, W, and A indicate before joining the wetland, within the wetland, and after passing through the wetland, respectively. dry and wet indicate dry season and wet season, respectively.

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Table S3. Percent reduction of organic and inorganic pollutants along the three wetlands.

	Boye		Fisho		Kitto	
	wet	dry	wet	dry	wet	dry
	% reduction	% reduction	% reduction	% reduction	% reduction	% reduction
TP	-18	74	-44	23	7	26
PO ₄ -P	-30	1	-7	-	-27	-
TN	-	6	-32	43	-	-91
NO ₃ -N	-	-	75	84	-	88
NH ₄ -N	5	-46	-	34	8	-99
DIN	20	-7	-12	62	-	73
EC	-35	-1	-5	-4	-20	6
DO	75	-72	-31	-41	-15	62
TUR	12	-39	38	-74	-1	57
Cl ⁻	31	-	-	-	84	97
BOD	77	6	-152	18	33	8

Table S4. Ethiobios index for the three wetland sites during the dry and wet season. Ethbios score > 115 = low level of degradation (high water quality); 65-114 = Slight ecological degradation (Good water quality); 45-64 = significant ecological disturbance (Moderate water quality); 12-44 = major degradation (poor water quality); <12 = heavily degraded ecological quality (bad water quality)

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Site code	Ethbios Score	
	Dry season	Wet season
B1	8	35
B2	23	10
B3	9	32
B4	31	27
B5	52	42
B6	66	53
B7	81	27
B8	49	16
F1	58	38
F2	20	32
F3	25	36
F4	50	63
F5	46	45
F6	47	46
K1	93	44
K2	59	51
K3	58	48
K4	32	47
K5	72	56
K6	58	59

Table S5. Identified **macroinvertebrate taxa** from dry and wet seasons. Macroinvertebrate code, taxa name and order respectively

Code	Family	Order	Code	Family	Order
Aes	<i>Aeshnidae</i>	odonata	lum	<i>Lumbriculidae</i>	Lumbriculida
bea	<i>Beatidae</i>	Ephemeroptera.	lym	<i>Lymnaeidae</i>	Hygrophila
bel	<i>Belostomatidae</i>	Hemiptera	mes	<i>Mesoveliidae</i>	Heteroptera
cae	<i>Caenidae</i>	Ephemeroptera	nau	<i>Naucoridae</i>	Hemiptera.
car	<i>Caratopogonidae</i>	Diptera	nep	<i>Nepidae</i>	Hemiptera
chi	<i>Chironomidae</i>	Diptera	not	<i>Notonectidae</i>	Hemiptera
clu	<i>Clucidae</i>	Mosquito	oli	<i>Oligochaeta</i>	oligochaeta
coe	<i>Coenagrionidae</i>	Odonata	phr	<i>Phrygonidae</i>	Trichoptera
corb	<i>Corbiculidae</i>	Veneroida	phy	<i>Physidae</i>	Basommatophora
cord	<i>Cordulidae</i>	Odonata	pis	<i>Pisauridae</i>	Araneae
cor	<i>Corixidae</i>	Hemiptera	plan	<i>Planorbidae</i>	Basommatophora.
cur	<i>Curculionidae</i>	Coleoptera	plat	<i>Platycnemidae</i>	odonata
dyt	<i>Dytiscidae</i>	Coleoptera	ple	<i>Pleidae</i>	Hemiptera
elm	<i>Elmidae</i>	Coleoptera	pot	<i>Potamonautidae</i>	Decapoda
eph	<i>Ephemerilidae</i>	Ephemeroptera	psy	<i>Psychodidae</i>	Diptera
epy	<i>Ephydriidae</i>	Diptera	pyr	<i>Pyalidae</i>	Lepidoptera
ger	<i>Gerridae</i>	Hemiptera	sci	<i>Sciomyzidae</i>	Diptera
glo	<i>Glossosomatidae</i>	Trichoptera	scr	<i>Scirtidae</i>	Coleoptera
gom	<i>Gomphidae</i>	Odonata	sim	<i>Simuliidae</i>	Diptera
gyr	<i>Gyrinidae</i>	Coleoptera	sph	<i>Sphaeriidae</i>	Veneroida
hep	<i>Heptageniidae</i>	Ephemeroptera.	syr	<i>Syrphidae</i>	Diptera
hir	<i>Hirudinea</i>	Arhynchobdellida	tab	<i>Tabanidae</i>	Diptera
hym	<i>Hydrometridae</i>	Hemiptera	thi	<i>Thiaridae</i>	Neotaenioglossa
hyd	<i>Hydrophilidae</i>	Coleoptera	tip	<i>Tipulidae</i>	Diptera
hyp	<i>Hydropsychidae</i>	Trichoptera	tub	<i>Tubificidae</i>	Haplotaxida
lep	<i>Leptoceridae</i>	Trichoptera	tur	<i>Turbellaria</i>	Acoela
les	<i>Lestidae</i>	Odonata	uni	<i>Unionidae</i>	Unionoida
lib	<i>Libellulidae</i>	Odonata	vel	<i>Velidae</i>	Hemiptera
lim	<i>Limoniidae</i>	Diptera			

Table S6. Diatom species identified in this study during dry and wet seasons. Species code, Omnidia code and species name of respectively.

Code	Omnidia code	Species	Code	Omnidia code	Species
AM	AMIS	<i>Achnanthes minuscula</i>	Gt	GTRU	<i>Gomphonema truncatum</i>
AG	ADEG	<i>Achnanthidium exiguum</i>	GU	GYKU	<i>Gyrosigma kuetzingii</i>
AX	ADEX	<i>Achnanthidium exile</i>	GB	GYOB	<i>Gyrosigma obtusatum</i>
AN	AMIN	<i>Achnanthidium minutissimum</i>	HO	HLMO	<i>Halamphora montana</i>
AG	ADSG	<i>Achnanthidium saprophilum</i>	HN	HVEN	<i>Halamphora veneta</i>
AH	ADSH	<i>Achnanthidium subhudsonis</i>	KS	KOPA	<i>kobayasias subtilissima</i>
AB	ABRY	<i>Adlfia bryophila</i>	LE	LGOE	<i>Luticola goeppertiana</i>
AC	ACOP	<i>Amphora copulata</i>	LT	LMUT	<i>Luticola mutica</i>
BT	BVIT	<i>Brachysira vitrea</i>	MT	MAAT	<i>Mayamaea atomus var atomus</i>
CT	CAQT	<i>Caloneis aequatorialis</i>	NN	NAAN	<i>Navicula angusta</i>
CB	CBAC	<i>Caloneis bacillum</i>	NT	NANT	<i>Navicula antonii</i>
CL	CLCT	<i>Caloneis lancettula</i>	NV	NARV	<i>Navicula arvensis</i>
CS	CSIL	<i>Caloneis silicula</i>	NC	NCPR	<i>Naviculapitatoradiata Germain</i>
CA	CPLA	<i>Cocconeis placentula</i>	NY	NCRY	<i>Navicula cryptocephala</i>
CM	CPLM	<i>Cocconeis placentula var lineta</i>	NE	NCTE	<i>Navicula cryptotenella</i>
CO	COPL	<i>Cocconeis Pseudolineta</i>	NO	NCTO	<i>Navicula cryptotenelloides</i>
CC	CRAC	<i>Craticula accomoda</i>	NI	NERI	<i>Navicula erifuga</i>
CAB	CAMB	<i>Craticula ambigua</i>	NR	NGRE	<i>Navicula gregaria</i>

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CU	CRBU	<i>Craticula buderi</i>	ND	NRAD	<i>Navicula radiosa</i>
CR	CRCU	<i>Craticula cuspidata</i>	NcS	NRCS	<i>Navicula recens</i>
CA	CHAL	<i>Craticula halophila</i>	NS	NROS	<i>Navicula rostelata</i>
CN	CMNO	<i>Craticula minusculoides</i>	NsR	NSHR	<i>Navicula schroeteri</i> <i>Meister</i>
CM	CMEN	<i>Cyclotella meneghiniana</i>	NSS	NSSY	<i>Navicula schroeteri</i> <i>var symmetrica</i>
CE	COCE	<i>Cyclotella ocellata</i> <i>Pantocsek</i>	NA	NSIA	<i>Navicula simulata</i>
CS	CAFS	<i>Cymbella affinis kutzing</i> <i>var. afarensis</i>	NF	NEAF	<i>Neidium affine</i>
CT	CTUR	<i>Cymbella turgidilla</i>	NI	NLGI	<i>Neidium longiceps</i>
DT	DCOT	<i>Diadesmis contenta</i>	NE	NBRE	<i>Neitzsichia brevissima</i>
ET	ECTT	<i>Encyonema caespitosum</i>	NP	NAMP	<i>Nitzschia amphibia</i>
EE	ESLE	<i>Encyonema silesiacum</i>	NPL	NCPL	<i>Nitzschia capitellata</i>
EN	EMIN	<i>Eunotia minor</i>	NA	NCLA	<i>Nitzschia clausii</i> <i>Hantzsch</i>
EI	EOMI	<i>Eolimna minima</i>	NS	NDIS	<i>Nitzschia dissipata</i>
EM	ESBM	<i>Eolimna subminuscule</i>	Nc	NIFRc	<i>Nitzschia frustulum</i>
ER	ESOR	<i>Epithemia sorex</i>	NN	NLIN	<i>Nitzschia linearis</i>
EL	EBIL	<i>Eunotia bilunaris</i>	NL	NPAL	<i>Nitzschia palea palea</i>
EC	EPEC	<i>Eunotia pectinalis</i>	NO	NSIO	<i>Nitzschia sigmoidea</i>
FG	FPYG	<i>Fallacia pygmaea</i>	PR	PACR	<i>Pinnularia acrosphaeria</i>
FN	FULN	<i>Fragilaria ulna</i>	PA	PBRA	<i>Pinnularia brauniana</i>
FS	FCRS	<i>Frastulia Crassinervia</i>	PB	PGIB	<i>Pinnularia gibba</i>
GC	GDEC	<i>Geissleria decussis</i>	PC	PMIC	<i>Pinnularia microstauron</i>
GF	GAFF	<i>Gomphonema affine</i>	PS	PSCA	<i>Pinnularia subcapitata</i>

GG	GAUG	<i>Gomphonema augur</i>	PI	PSGI	<i>Pinnularia subgibba</i>
Gr	GPUMr	<i>Gomphonema cf pumillum</i> <i>var pumillum</i>	PR	PLFR	<i>Planothidium</i> <i>frequentissimum</i>
GA	GGRA	<i>Gomphonema gracile</i>	PT	PRST	<i>Planothidium</i> <i>rostratum</i>
GS	GMIS	<i>Gomphonema minusculum</i>	RT	RSIT	<i>Reimeria sinuata</i>
GN	GMIN	<i>Gomphonema minutum</i>	RB	RABB	<i>Rhoicosphenia</i> <i>abbreviata</i>
GL	GPVL	<i>Gomphonema parvulus</i>	SP	SPUP	<i>Sellaphora pupula</i>
GR	GPAR	<i>Gomphonema parvulum</i> <i>var. parvulum</i>	SN	STAN	<i>Stauroneis anceps</i>
GP	GPSA	<i>Gomphonema</i> <i>pseudoaugur</i>	SR	SSGR	<i>Stauroneis subgracilis</i>
GU	GPUM	<i>Gomphonema pumilum</i>		SANG	<i>Surirella angusta</i>
Gr	GPUMr	<i>Gomphonema pumilum</i> <i>var rigidua</i>	UN	UULN	<i>Ulnaria ulna</i>

Table S7. Spearman correlation between environmental variables and macroinvertebrate metrics. (%FC = relative abundance of filter collectors, S= species richness, and H=Shannon's diversity)

Wet (n=20)	TN	DIN	TP	PO ₄ -P	PH	EC	DO	Turb	BOD
%FC	-0.21	0.39	-0.24	0.17	-0.32	-0.24	-0.41	-0.27	0.26
S	-0.38	0.83*	-0.74*	-0.56*	-0.68*	-0.49*	-0.33	-0.72*	0.19
H	-0.3	-0.53*	-0.6*	-0.36	-0.54*	-0.59*	-0.34	-0.7*	0.49*
Ethbios	-0.32	0.76*	-0.62*	-0.4	-0.62*	-0.44	-0.19	-0.42	0.28
abundance	-0.03	0.03	0.03	0.04	0.16	0.23	0.42	0.14	-0.04
Dry (n=20)									
%FC	-0.35	-0.25	-0.63*	-0.5*	-0.66*	-0.49*	0.02	-0.12	-0.16
S	-0.4	-0.12	0.01	-0.19	-0.13	-0.45*	-0.03	0.32	-0.07
H	-0.18	-0.24	-0.05	0	-0.21	-0.14	-0.19	0.18	-0.3
Ethbios	-0.48*	-0.2	-0.11	-0.26	-0.13	-0.44	-0.06	0.28	-0.03
Abundance	-0.12	0.15	0.43	0.09	0.35	-0.03	-0.28	0.23	0.28

* Indicates statistical significance (P<0.05)

Table S8. Spearman correlation between environmental variables and diatom metrics

Wet (n=15)	TP	TN	PO ₄ -P	DIN	PH	EC	DO	Turb	BOD
PT	0.19	0.4	0.6*	0.68*	0.52*	0.42	0.26	0.57*	0.26
S	-0.14	0.09	-0.03	-0.1	0.27	-0.08	-0.31	0.06	0.002
H	-0.12	0.32	0.05	-0.06	0.27	0.02	-0.28	0.11	0.11
Dry (n=15)									
PT	0.52*	0.48*	0.4	0.57*	0.42	0.41	-0.16	0.5*	-0.12
S	-0.24	-0.44	-0.26	-0.01	0.11	-0.32	0.46*	0.12	0.03
H	-0.4	-0.44	-0.34	-0.12	-0.23	-0.51*	0.55*	-0.09	0.03

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Table S9. Measured environmental parameters in each sites during wet and dry seasons (n = 20).

Wet season													
Site	TUR	EC	TP	PO4-P	TN	BOD	DO	PH	T°	NO3-N	NH4-N	DIN	Cl-
B1	407.0	228.0	2.26	0.12	2.57	16.0	3.75	7.82	22.2	1.33	0.11	1.44	17.99
B2	41.1	339.0	0.49	0.29	4.76	4.9	2.93	7.93	23.6	2.29	0.08	2.37	24.99
B3	122.3	197.4	0.61	0.19	5.65	6.3	6.25	8.05	23.3	1.65	0.13	1.78	14.99
B4	68.4	79.3	0.31	0.10	2.12	8.4	7.24	7.75	18.8	0.99	0.11	1.09	7.98
B5	42.1	75.3	0.16	0.06	0.91	11.8	4.46	7.26	23.6	0.26	0.12	0.38	4.99
B6	74.2	78.5	0.21	0.08	0.83	3.1	5.2	7.57	23.3	1.07	0.12	1.19	6.98
B7	47.4	85.1	0.20	0.08	1.08	4.8	3.67	7.44	20.9	0.77	0.09	0.85	4.99
B8	48.0	107.7	0.22	0.10	3.20	1.5	1.13	7.14	21	0.53	0.12	0.65	6.97
F1	55.0	90.9	0.18	0.07	11.60	3.3	5.04	7.33	19.8	0.63	0.01	0.64	3.99
F2	7.7	70.0	0.13	0.05	0.68	1.5	5.99	6.25	28.1	0.24	0.10	0.34	5.99
F3	48.7	77.3	0.20	0.10	2.37	4.5	4.55	7.43	23	0.51	0.12	0.64	4.98
F4	21.5	83.8	0.15	0.05	0.76	3.9	3.29	7.48	22.2	0.02	0.12	0.14	5.97
F5	34.2	59.9	0.19	0.09	0.88	1.8	4.55	7.32	23.3	0.21	0.00	0.22	2.99
F6	28.0	74.4	0.15	0.01	1.71	5.4	5.01	7.48	25.4	0.16	0.11	0.27	2.99
K1	32.9	76.6	0.16	0.06	0.50	0.9	2.79	7.17	21.7	0.18	0.11	0.29	4.99
K2	20.1	81.1	0.16	0.02	1.38	0.5	3.01	7.3	19.5	0.72	0.10	0.82	4.00
K3	20.8	78.2	0.15	0.05	0.71	1.2	2.6	7.47	21	0.48	0.10	0.57	3.99
K4	19.4	79.3	0.19	0.05	0.77	1.2	3.68	7.35	21.5	0.38	0.10	0.48	2.98
K5	15.7	82.6	0.29	0.04	1.11	0.9	3.75	7.55	22	0.54	0.10	0.64	4.00
K6	17.0	83.3	0.17	0.04	1.36	2.5	3.87	7.3	22.5	0.51	0.10	0.61	3.91
Dry season													
Site													
B1	15.4	495.0	0.38	0.20	6.35	30.0	1.4	8.76	25.1	0.21	3.11	3.32	2.50
B2	18.8	605.0	0.89	0.56	13.30	165.0	2.48	8.78	25.7	2.66	6.22	8.88	2.00
B3	28.3	1142.0	4.99	4.25	43.20	33.3	1.59	8.97	24.3	0.38	3.08	3.46	2.50
B4	25.0	244.0	0.57	0.19	4.83	23.3	0.43	8.3	22.1	0.19	2.88	3.07	3.00
B5	41.6	230.0	0.32	0.09	2.24	13.3	11.29	8.45	33.2	0.68	0.11	0.80	3.50
B6	67.8	192.4	0.35	0.01	2.31	17.3	1.95	8.18	27.5	0.08	0.78	0.86	3.25
B7	52.9	197.5	0.12	0.04	1.51	13.3	1.34	8.42	26.8	0.04	0.88	0.92	2.01
B8	30.7	231.0	0.05	0.03	1.40	12.0	4.47	8.2	22.7	0.00	1.29	1.29	2.25
F1	16.6	74.8	0.03	0.01	3.10	10.0	4.45	7.51	25	0.52	0.05	0.57	2.00

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F2	22.2	225.0	0.04	0	1.13	21.3	2.32	7.95	24.3	0.00	0.00	0.01	8.50
F3	23.3	70.6	0.00	0	0.98	14.0	7.31	6.98	24.6	0.66	0.02	0.68	9.50
F4	27.9	166.7	0.04	0	2.64	36.7	2.15	7.83	23.3	2.07	0.21	2.28	13.50
F5	33.1	186.0	0.05	0	1.37	18.6	4.28	7.92	23.8	0.08	0.10	0.19	20.49
F6	34.6	125.4	0.01	0	1.05	20.9	5.29	8.15	24.6	0.00	0.03	0.03	7.50
K1	50.9	166.7	0.14	0	0.00	29.3	6.74	8.99	18	1.27	0.02	1.29	75.48
K2	8.6	199.0	0.02	0.01	1.19	101.3	0.76	7.93	22.1	0.00	0.10	0.10	41.49
K3	23.5	228.0	0.06	0.01	1.04	60.0	1.28	7.81	22.8	0.12	0.07	0.19	3.50
K4	9.8	178.0	0.03	0	7.75	16.0	1.04	8.01	25	0.00	0.09	0.09	36.49
K5	20.4	171.6	0.05	0	0.60	83.3	1.23	7.89	23.5	0.10	0.14	0.24	2.50
K6	5.2	171.8	0.06	0.01	1.67	53.3	1.59	8.09	24.1	0.05	0.09	0.14	1.50

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