

Supplementary Information

Assessment of Spatiotemporal Variations in the Water Quality of the Han River Basin, South Korea, using Multivariate Statistical and APCS-MLR Modeling Techniques

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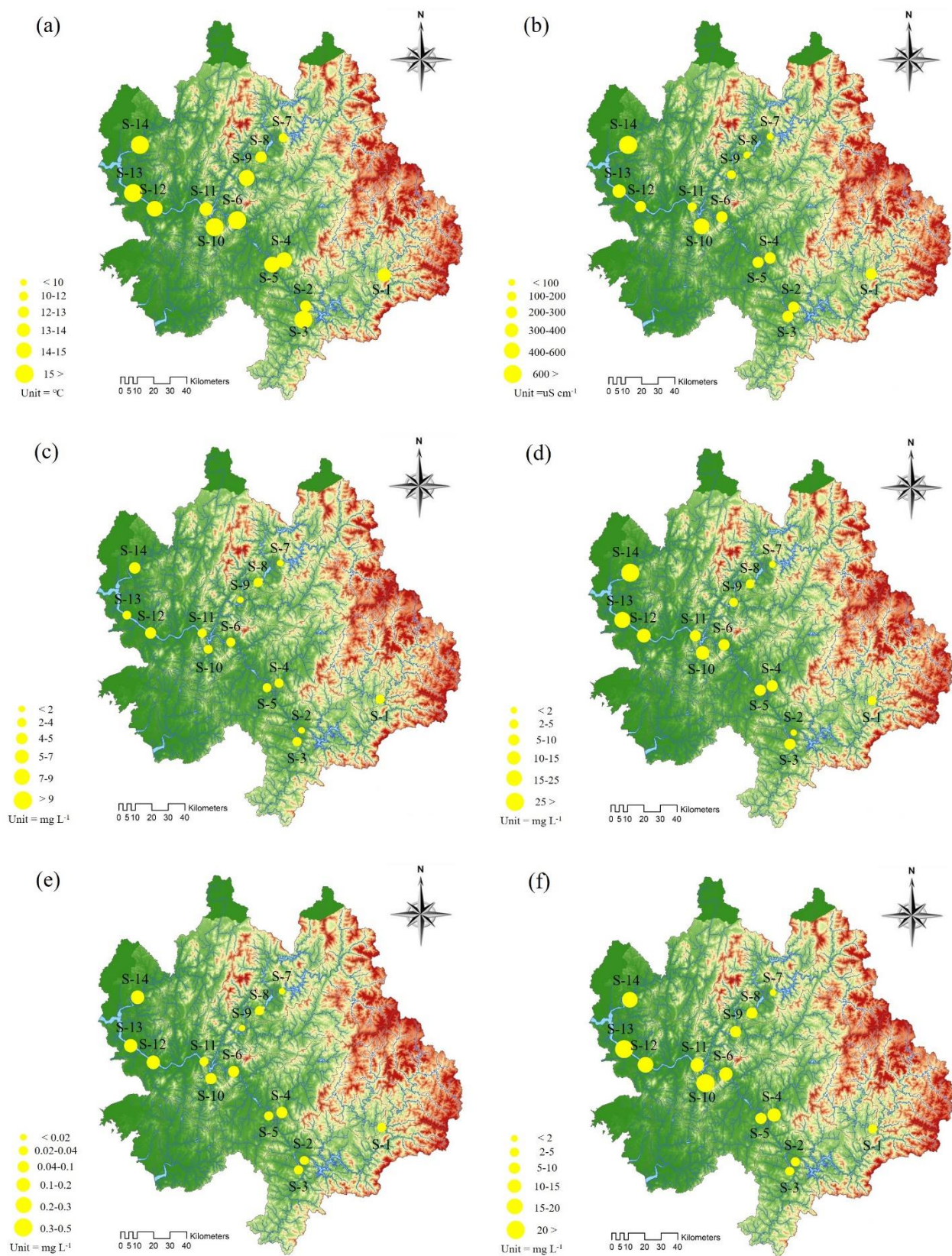


Figure S1. Spatial variation of water quality parameters in the monitoring sites of Han River Basin, South Korea. (a) WT, (b) EC, (c) COD, (d) TSS, (e) TP and (f) Chl-*a*.

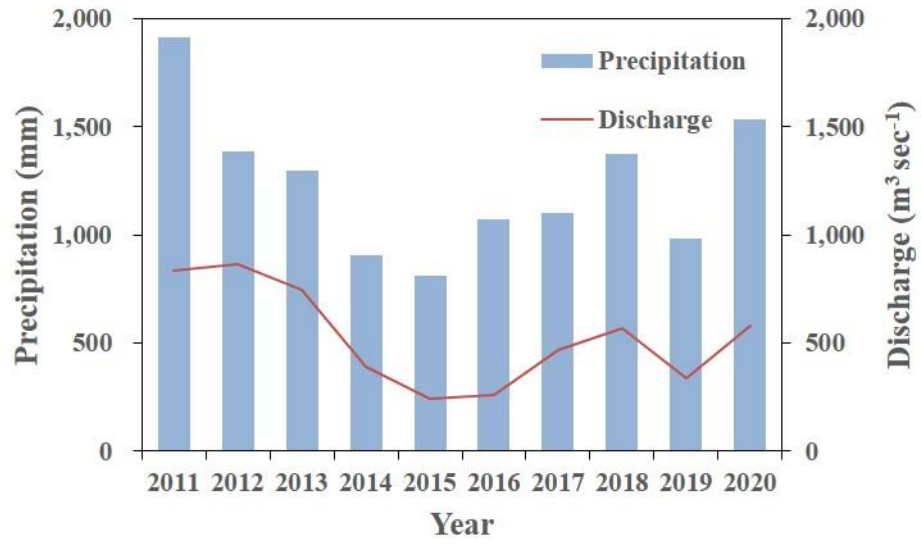


Figure S2. Precipitation and discharge in the Han River Basin from 2011 to 2020.

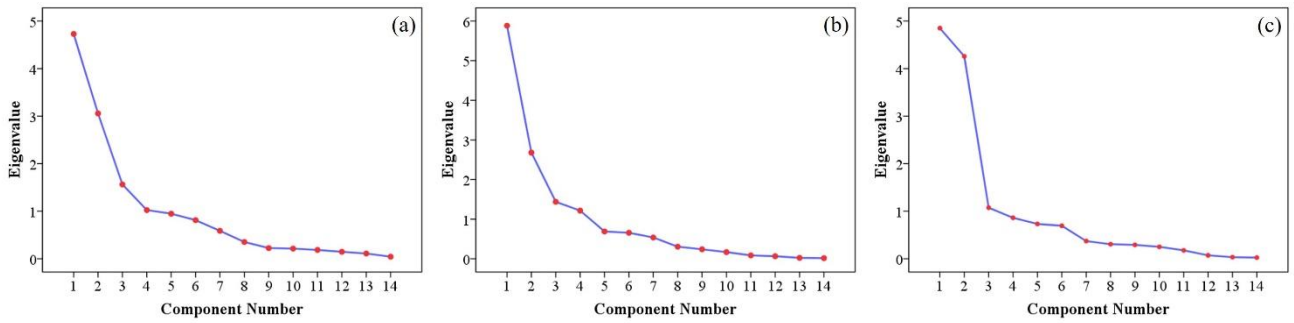


Figure S3. Eigenvalue change with number of principal components. (a) MPR, (b) LPR and (c) HPR.

Table S1. Information of analytical methods and instrument.

Parameters	Unit	Analytical methods	Analytical Instrument
WT	°C	Temperature probe	600 XLM (YSI, USA)
pH	-	pH probe	600 XLM (YSI, USA)
EC	$\mu\text{S cm}^{-1}$	Conductometry	600 XLM (YSI, USA)
DO	mg L^{-1}	Do probe	600 XLM (YSI, USA)
BOD	mg L^{-1}	Winkler azide method	DO Meter (YSI 5910), BOD Incubator
COD	mg L^{-1}	KMnO ₄ method	Water Bath (100 °C Acid)
TSS	mg L^{-1}	Gravimetric	Whatman GF/C Filter
TN	mg L^{-1}	Continuous flow analysis	AACS_VI (BLTEC, Japan)
NH ₃ -N	mg L^{-1}	Continuous flow analysis	AACS_VI (BLTEC, Japan)
NO ₃ -N	mg L^{-1}	SmartChem	SmartChem 200 (AMS Alliance, USA)
TP	mg L^{-1}	Continuous flow analysis	AACS_VI (BLTEC, Japan)
PO ₄ -P	mg L^{-1}	SmartChem	SmartChem 200 (AMS Alliance, USA)
TOC	mg L^{-1}	High temperature combustion oxidation	TOC-LCPH (Shimadzu, Japan)
Chl-a	mg m^{-3}	UV-Visible Spectrophotometer	Agilent technologies (AU/Carry 3500, USA)

Table S2. Summary descriptive statistics of water quality parameters between 2011 and 2020.

Sites	Statistics	WT	pH	EC	DO	BOD	COD	TOC	TSS	TN	NH ₃ -N	NO ₃ -N	TP	PO ₄ -P	Chl-a
S-1 (N=119)	Min.	0.3	7.5	166	8.8	0.2	1.6	0.6	0.3	1.516	0.001	1.065	0.005	0.000	0.5
	Mean	14.3	8.4	265	12.0	1.1	2.9	2.2	4.0	3.160	0.048	2.381	0.030	0.014	3.0
	Max.	27.3	9.2	390	18.3	2.4	5.6	4.7	33.9	6.698	0.212	3.620	0.454	0.414	11.9
	S. D.	8.1	0.3	43	2.2	0.4	0.7	0.7	4.7	0.773	0.029	0.547	0.050	0.044	2.4
S-2 (N=119)	Min.	3.7	7.5	149	5.0	0.3	1.8	0.7	0.2	1.729	0.002	1.225	0.005	0.000	0.6
	Mean	13.1	8.1	218	9.9	0.8	2.6	2.0	1.9	2.519	0.062	1.866	0.023	0.009	2.1
	Max.	24.0	8.8	286	22.9	1.8	4.3	3.3	14.0	5.066	0.184	2.609	0.273	0.095	7.4
	S. D.	5.9	0.3	26	2.7	0.3	0.5	0.5	1.6	0.496	0.035	0.253	0.028	0.010	1.2
S-3 (N=119)	Min.	0.0	7.3	133	7.5	0.2	1.9	0.1	0.5	0.777	0.003	0.059	0.006	0.000	0.5
	Mean	15.9	8.2	12.4	12.4	1.1	2.5	2.5	3.1	2.381	0.057	1.704	0.036	0.010	3.8
	Max.	30.7	9.1	20.3	20.3	2.0	6.0	6.0	50.6	6.370	0.239	3.787	0.236	0.082	13.8
	S. D.	9.0	0.4	2.5	2.5	0.4	0.9	0.9	6.9	0.970	0.039	0.716	0.038	0.011	2.4
S-4 (N=119)	Min.	0.3	7.2	90	8.2	0.5	2.7	1.6	1.0	0.912	0.004	0.304	0.015	0.001	1.5
	Mean	14.7	8.1	268	11.7	1.5	4.8	2.9	9.5	3.553	2.478	2.478	0.072	0.035	11.4
	Max.	28.5	9.1	518	16.6	3.6	13.5	10.7	331.5	8.184	4.813	4.200	0.241	0.180	62.0
	S. D.	9.1	0.4	83.4	1.9	0.7	1.4	1.0	30.9	1.494	0.825	0.872	0.047	0.037	11.7
S-5 (N=119)	Min.	2.5	7.5	90	7.9	0.4	2.0	1.3	1.4	1.419	0.005	1.020	0.013	0.000	0.8
	Mean	14.3	8.1	234	11.4	1.1	3.6	2.1	7.5	2.506	0.062	2.031	0.040	0.016	7.5
	Max.	27.4	9.0	305	15.6	2.9	5.9	4.0	55.7	3.760	0.289	3.155	0.179	0.100	35.0
	S. D.	7.4	0.3	32.6	1.8	0.5	0.7	0.5	8.7	0.381	0.060	0.381	0.029	0.019	6.3
S-6 (N=116)	Min.	1.6	7.4	134	7.8	0.4	2.3	1.4	0.8	1.402	0.008	0.913	0.016	0.000	0.4
	Mean	15.0	8.1	251	11.4	1.4	4.0	2.3	9.2	2.623	0.079	2.116	0.046	0.016	11.1
	Max.	29.5	9.0	347	14.8	3.7	7.0	3.9	162.8	3.770	0.415	3.073	0.168	0.070	56.7
	S. D.	8.2	0.4	43.1	1.7	0.8	0.8	0.5	18.0	0.445	0.068	0.423	0.027	0.016	9.6
S-7 (N=119)	Min.	4.3	7.1	51	8.7	0.2	2.0	1.1	0.3	1.277	0.001	1.071	0.004	0.000	0.4
	Mean	9.8	8.0	73	12.0	0.3	2.7	1.6	2.2	1.606	0.011	1.383	0.013	0.002	1.8
	Max.	20.2	8.7	95	14.3	0.8	3.8	2.4	15.8	2.164	0.044	1.855	0.068	0.017	4.5
	S. D.	3.5	0.3	9.4	12.0	0.1	0.4	0.2	3.0	0.197	0.007	0.165	0.013	0.003	0.9

Sites	Statistics	WT	pH	EC	DO	BOD	COD	TOC	TSS	TN	NH ₃ -N	NO ₃ -N	TP	PO ₄ -P	Chl-a
S-8	Min.	2.9	7.3	73	7.6	0.2	1.2	1.2	1.0	1.114	0.019	0.809	0.06	0.000	1.4
(N=119)	Mean	13.2	8.0	96	11.4	1.2	3.1	2.0	4.0	1.919	0.100	1.313	0.020	0.006	7.3
	Max.	24.6	9.6	138	16.5	2.5	5.3	3.0	35.0	4.147	0.256	2.134	0.099	0.043	24.2
	S. D.	6.4	0.4	13	1.8	0.4	0.6	0.4	4.0	0.543	0.055	0.258	0.015	0.005	3.9
S-9	Min.	0.5	7.1	76	7.8	0.4	2.3	1.2	0.9	1.263	0.005	1.047	0.008	0.000	1.7
(N=114)	Mean	14.2	7.8	116	10.9	0.9	3.3	1.9	3.7	1.831	0.049	1.494	0.018	0.002	8.3
	Max.	28.8	8.7	228	14.9	1.8	5.2	3.7	16.4	2.994	0.255	2.434	0.059	0.013	23.5
	S. D.	7.9	0.3	23.2	1.7	0.3	0.5	0.3	2.8	0.281	0.045	0.242	0.010	0.002	4.7
S-10	Min.	1.5	6.7	142	7.9	0.7	3.1	1.3	1.8	2.003	0.011	1.339	0.017	0.003	1.8
(N=119)	Mean	15.3	7.9	410	11.2	2.2	5.9	2.8	13.3	4.528	0.543	3.294	0.062	0.022	25.6
	Max.	29.3	8.8	623	16.1	5.9	11.7	5.5	58.3	9.357	4.115	6.232	0.165	0.126	144.9
	S. D.	8.4	0.4	95	1.9	1.2	1.6	0.6	9.6	1.820	0.771	1.123	0.030	0.022	27.1
S-11	Min.	0.9	7.2	104	4.3	0.6	2.5	1.3	1.3	1.316	0.009	0.885	0.009	0.000	2.2
(N=119)	Mean	13.5	7.9	184	10.4	1.2	3.7	2.2	6.5	2.167	0.060	1.753	0.032	0.007	12.1
	Max.	26.5	8.8	271	15.0	2.1	5.2	3.3	67.0	3.092	0.266	2.612	0.117	0.048	31.2
	S. D.	7.6	0.4	37	2.3	0.3	0.5	0.3	7.8	0.370	0.040	0.347	0.020	0.009	5.5
S-12	Min.	1.5	7.3	117	5.6	0.8	3.7	1.9	2.6	2.295	0.082	1.582	0.040	0.002	3.0
(N=119)	Mean	15.0	7.8	258	10.2	2.3	5.2	3.3	10.7	4.577	0.763	2.947	0.134	0.074	18.6
	Max.	28.3	8.7	566	16.4	5.5	9.2	6.4	86.0	11.820	3.023	7.527	0.316	0.233	89.2
	S. D.	8.2	0.3	75	2.3	1.0	1.0	0.8	10.3	1.426	0.561	0.933	0.070	0.065	13.1
S-13	Min.	1.5	7.3	108	6.1	0.6	3.2	1.5	3.7	2.349	0.043	1.431	0.028	0.004	2.6
(N=116)	Mean	15.4	7.9	340	10.6	2.3	5.5	2.7	17.6	4.234	0.721	2.824	0.119	0.065	24.9
	Max.	28.5	8.7	2140	16.4	6.0	10.7	4.7	52.9	11.850	4.355	6.415	0.282	0.225	119.9
	S. D.	8.3	0.3	230	2.4	1.2	1.2	0.5	10.4	1.444	0.616	0.916	0.055	0.051	20.2
S-14	Min.	0.9	6.9	108	6.9	0.4	3.1	1.3	10.6	1.376	0.017	0.891	0.037	0.007	0.4
(N=117)	Mean	15.3	7.8	1124	10.8	1.8	6.7	3.2	84.7	3.294	0.420	2.214	0.132	0.036	16.4
	Max.	29.4	8.7	5653	16.8	4.4	14.9	7.9	251.6	6.857	2.802	3.445	0.373	0.099	93.4
	S. D.	9.0	0.3	1192	2.5	1.0	2.3	1.2	45.7	1.110	0.560	0.614	0.068	0.017	14.1

Table S4. Descriptive statistics of water quality variables in different clusters in Han River Basin.

Parameters	MPR				LPR				HPR			
	Mean	Min.	Max.	S. E.	Mean	Min.	Max.	S. E.	Mean	Min.	Max.	S. E.
WT	14.5	0.9	28.5	0.43	13.9	0.1	30.7	0.23	15.2	0.9	29.4	0.85
pH	7.9	7.2	8.8	0.02	8.1	6.7	9.6	0.01	7.8	7.2	8.7	0.03
EC	261	104	2140	8.24	216	51	623	3.14	1165	134	5653	114.09
DO	10.4	4.3	16.4	0.13	11.4	5.0	22.9	0.06	10.8	6.9	15.6	0.23
BOD	1.9	0.6	6.0	0.06	1.2	0.2	5.9	0.02	1.9	0.5	4.4	0.09
COD	4.8	2.5	10.7	0.06	3.6	1.2	13.5	0.04	6.8	3.1	14.9	0.21
TOC	2.7	1.3	6.4	0.04	2.2	0.1	10.7	0.02	3.2	1.3	7.9	0.12
TSS	11.4	1.3	86.0	0.56	5.9	0.2	331.5	0.38	85.4	10.6	251.6	4.29
TN	3.667	1.316	11.850	0.09	2.660	0.777	9.969	0.04	3.310	1.376	6.857	0.11
NH ₃ -N	0.521	0.009	4.355	0.03	0.151	0.001	4.813	0.01	0.423	0.017	2.802	0.05
NO ₃ -N	2.509	0.885	7.527	0.05	2.001	0.059	6.575	0.02	2.220	0.891	3.445	0.06
TP	0.095	0.009	0.316	0.004	0.036	0.004	0.454	0.001	0.133	0.037	0.373	0.01
PO ₄ -P	0.049	0.000	0.233	0.003	0.013	0.000	0.414	0.001	0.035	0.007	0.009	0.002
Chl-a	18.7	2.2	119.9	0.81	8.2	0.4	144.9	0.36	16.8	1.2	93.4	1.34