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Supplementary Material

Water Quality Assessment and Potential Source Contribution Using Multivariate Statistical Techniques in Jinwi River Watershed, South Korea

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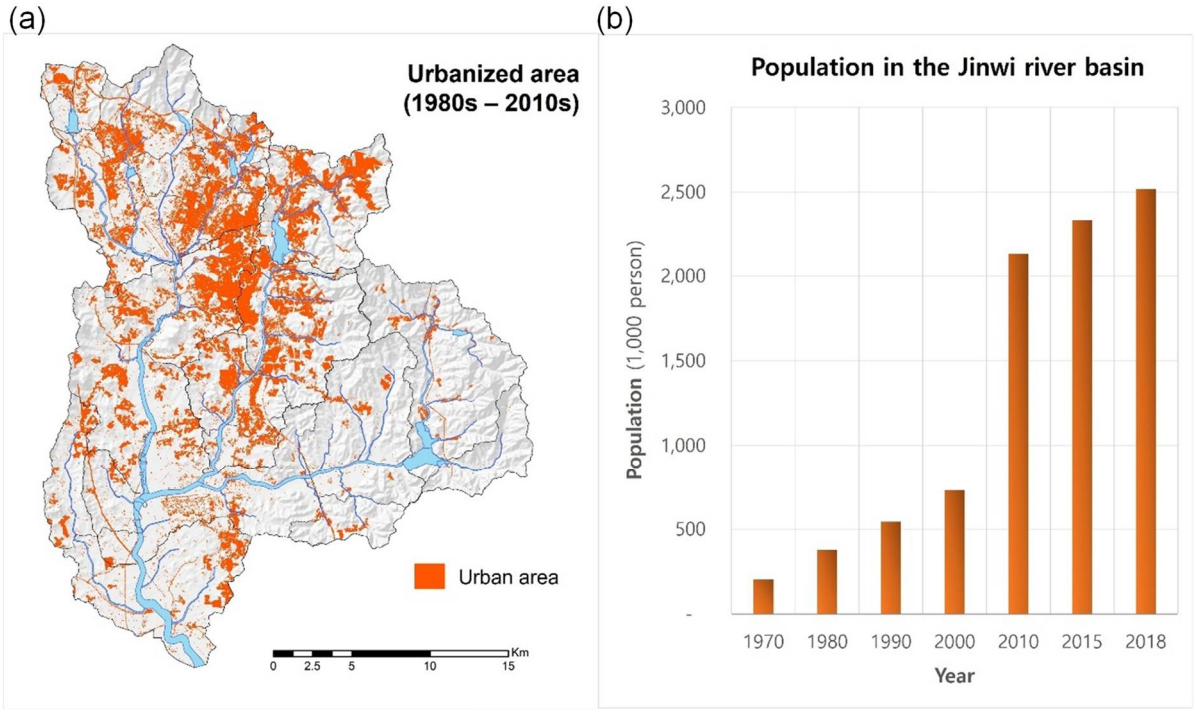


Figure S1. Urbanized area (1980s–2010s) (**a**) and population change (**b**) in the Jinwi River watershed [1,2].

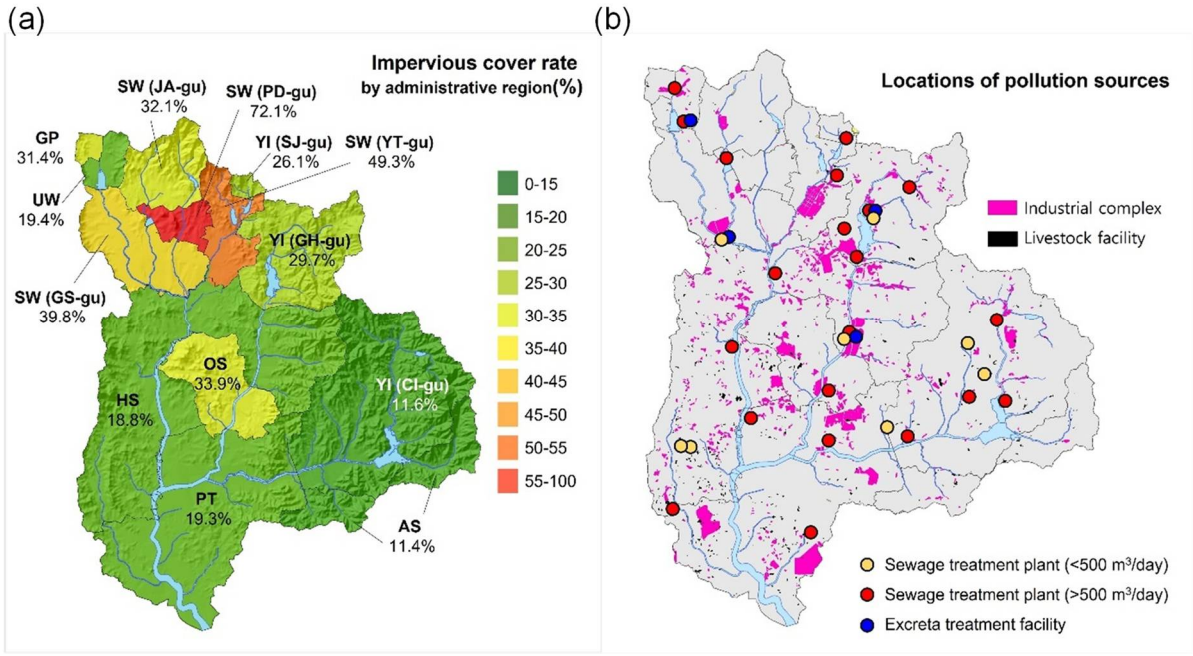


Figure S2. Impervious cover rate (**a**) and locations of pollution sources (**b**) in the Jinwi River watershed [1,3].

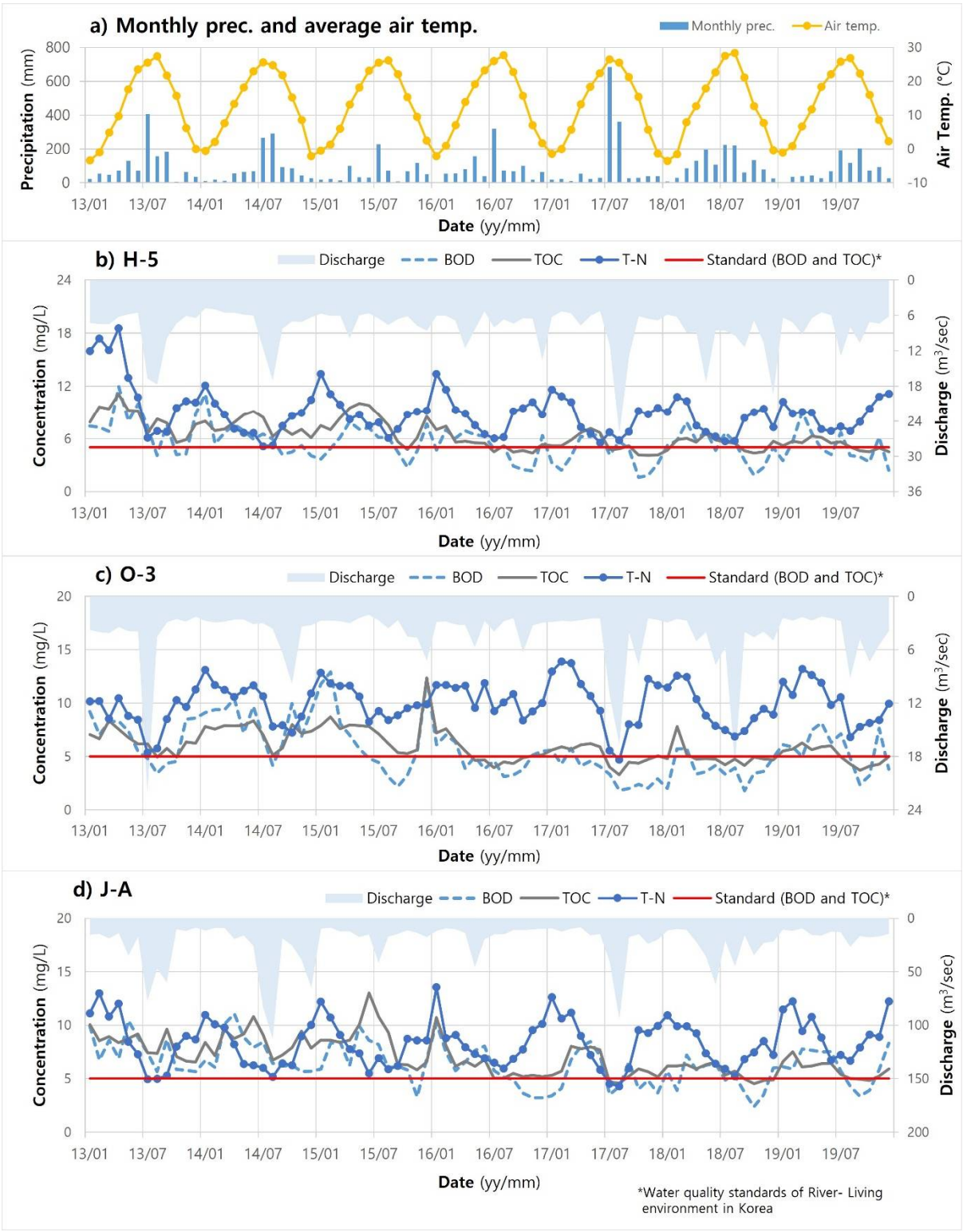


Figure S3. Monthly precipitation and air temperature data from (**a**) Suwon weather station, and changes of water quality concentration and discharge at (**b**) H-5, (**c**) O-3 and (**d**) J-A.

Table S1. List of monitoring sites in the Jinwi River Basin and their characteristics.

Site	Drainage area (km²)	Boundary between cities	TM coordinates	
			X	Y
J-1	20.57	Anseong - Yongin	219863.786	500892.545
S-T	15.57	Anseong - Yongin	212980.152	499155.883
J-2	135.53	Yongin - Pyeongtaek	210642.764	500071.279
O-1	57.16	Yongin - Hwaseong	208057.620	512726.384
O-2	52.89	Hwaseong - Osan	206985.257	506565.967
O-3	27.23	Osan - Pyeongtaek	205185.963	503441.802
H-1	4.23	Gunpo - Uiwang	284082.364	525044.353
H-2	10.92	Uiwang - Suwon	283891.212	522492.551
H-3	154.47	Suwon - Hwaseong	202263.735	511594.516
H-4	21.95	Osan - Hwaseong	200828.773	509402.372
H-5	52.46	Hwaseong - Pyeongtaek	200128.372	502204.015
J-3	99.72	Hwaseong - Pyeongtaek	288373.416	498143.720
G-T	20.5	Hwaseong - Pyeongtaek	284982.604	496323.776
J-A	61.08	End of the Jinwi River	201684.668	546122.857

Table S2. Information of analytical methods and instruments.

Parameters	Unit	Analytical methods	Analytical Instrument	QA/QC [4]
WT	℃	Temperature probe	600 XLM (YSI, Yellow Springs, OH, USA)	-
pH	-	pH probe	600 XLM (YSI, Yellow Springs, OH, USA)	-
EC	μS/cm	Conductometry	600 XLM (YSI, Yellow Springs, OH, USA)	Precision: *RSD ≤ ±20%
DO	mg/L	DO probe	600 XLM (YSI, Yellow Springs, OH, USA)	**LOQ: 0.5 mg/L Accuracy: 95─105%
BOD	mg/L	Winkler azide method	5100 DO Meter (YSI, Yellow Springs, OH, USA), BOD Incubator (VISION Scientific, Bucheon, South Korea)	Precision: RSD ≤ ±15% Accuracy: 95–105%
COD	mg/L	$KMnO_4$ method	Water Bath (100 ℃ Acid)	Precision: RSD ≤ ±25% Accuracy: 75–125%
SS	mg/L	Gravimetric	GF/C Filter (Whatman, Maidstone, UK)	-
T-N	mg/L	Continuous flow analysis	AACS_VI (BLTEC, Tokyo, Japan)	LOQ: 0.06 mg/L Precision: RSD ≤ ±25%
T-P	mg/L	Continuous flow analysis	AACS_VI (BLTEC, Tokyo, Japan)	LOQ: 0.003 mg/L Precision: RSD ≤ ±25%
TOC	mg/L	High temperature combustion oxidation	TOC-LCPH (Shimadzu, Tokyo, Japan)	LOQ: 0.3 mg/L Precision: RSD ≤ ±20% Accuracy: 80–120%
Chl-*a*	mg/m^3	UV-Visible Spectrophotometer	Agilent technologies (AU/Carry 3500, Santa Clara, CA, USA)	-

*RSD: Relative standard deviation.
**LOQ: Limit of quantitation.

Table S3. Water quality parameters and scores.

Parameter	Score range						
	1	**2**	**3**	**4**	**5**	**6**	**7**
BOD (mg/L) *	≤1	≤2	≤3	≤5	≤8	≤10	above 10
COD (mg/L) *	≤2	≤4	≤5	≤7	≤9	≤11	above 11
T-P (mg/L) *	≤0.02	≤0.04	≤0.1	≤0.2	≤0.3	≤0.5	above 0.5
TOC (mg/L) *	≤2	≤3	≤4	≤5	≤6	≤8	above 8
BOD load ($kg/d/km^2$)	≤1.6	≤1.9	≤3.3	≤10.5	≤77.6	≤171.1	above 171.1
COD load ($kg/d/km^2$)	≤4.3	≤5.0	≤10.4	≤23.7	≤132.2	≤310.0	above 310.0
T-N load ($kg/d/km^2$)	≤1.7	≤1.8	≤4.9	≤21	≤102.3	≤199.1	above 199.1
T-P load ($kg/d/km^2$)	≤0.06	≤0.08	≤0.17	≤0.65	≤6.77	≤12.55	above 12.55
TOC load ($kg/d/km^2$)	≤2.6	≤3.0	≤6.1	≤15.6	≤84.6	≤196.8	above 196.8

* Water quality standards of river-living environment in Korea [5].

Table S4. Information of water quality index.

- Water quality range for RTWQI [6]

Parameter	Range
Water temperature	Monthly average for 10 year – 10 °C ≤ WT(°C) ≤ Monthly average for 10 year + 10 °C
pH	6.5 ≤ pH ≤ 9.0
DO	0.8 × DO saturation concentration at present water temperature ≤ DO ≤ 1.3 × DO saturation concentration at present water temperature
EC	EC ≤ 300 μS/cm
SS	SS ≤ 25 mg/L
T-N	T-N ≤ 3.0 mg/L
T-P	T-P ≤ 0.1 mg/L
TOC	TOC ≤ 3.0 mg/L

- The mathematical formulation of RTWQI is given below:

$$RTWQI = 100 - \left(\sqrt{\frac{F_1^2 + F_2^2 + F_3^2}{3}}\right)$$

where F1 is the number of variables whose objectives are not met (failed variables), F2 is the percentage of individual tests that do not meet objectives (failed tests), F3 is the amount by which failed test values do not meet their objectives and is then calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range between 0 and 100 [6,7].

- Descriptions of scores and grades of RTWQI [7].

RTWQI		Description
Score	Grade	
80–100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
60–79	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
40–59	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
20–39	Poor	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0–19	Very poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Table S5. Seven-year average value in the dry season and the wet season on monitoring site.

Site	WT (°C)	pH	EC (μS/cm)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	SS (mg/L)	T-N (mg/L)	T-P (mg/L)	TOC (mg/L)	Chl-*a* (mg/m³)	D (m³/s)
Dry season (April–June)												
J-1	18.5	7.9	247	9.9	1.2	4.7	8.1	2.135	0.051	2.8	4.2	0.188
S-T	19.1	7.6	355	10.2	2.6	6.4	14.4	2.297	0.106	3.7	8.0	0.131
J-2	21.5	8.1	315	11.6	2.2	6.6	12.3	2.233	0.094	4.0	9.7	1.383
O-1	24.4	7.4	2668	9.0	1.6	7.0	6.4	11.171	0.227	5.0	6.2	0.941
O-2	21.8	7.8	1563	10.0	2.8	6.9	18.0	7.195	0.246	4.5	19.9	1.908
O-3	22.5	7.5	1163	9.4	5.9	9.7	13.9	10.372	0.566	6.3	14.6	3.371
H-1	20.2	7.7	513	10.3	3.4	7.8	13.5	9.004	0.185	5.2	10.1	0.106
H-2	21.2	8.7	471	11.8	7.8	14.7	30.3	3.426	0.147	7.2	0.1	0.102
H-3	22.7	7.3	1149	8.1	8.2	12.2	17.3	9.236	0.655	7.6	8.1	8.085
H-4	22.6	7.3	1263	7.2	6.2	11.4	12.9	8.946	0.612	7.3	8.4	8.441
H-5	23.0	7.7	1170	9.5	6.9	11.8	19.0	8.234	0.634	7.5	44.4	7.283
J-3	21.3	7.7	1050	9.2	6.9	11.5	21.1	7.896	0.535	7.2	50.9	15.121
G-T	22.9	8.0	788	9.5	6.0	12.6	17.5	5.512	0.255	8.2	26.6	0.492
J-A	20.7	7.8	1053	8.8	7.9	12.9	20.9	7.747	0.479	8.0	81.5	21.623
Wet season (July–September)												
J-1	23.4	7.8	225	8.2	0.9	4.0	6.0	1.876	0.046	2.3	3.9	0.418
S-T	24.4	7.6	346	8.8	1.4	5.1	6.0	2.506	0.087	3.1	2.6	0.246
J-2	25.7	7.7	293	9.7	1.2	5.0	7.0	2.027	0.063	3.1	6.4	3.480
O-1	27.9	7.5	2298	8.2	1.4	6.4	8.0	10.093	0.183	4.3	7.1	1.734
O-2	26.1	7.7	1249	9.1	1.9	5.9	19.2	5.910	0.209	3.8	17.9	4.508
O-3	26.9	7.5	999	8.6	3.9	7.7	16.7	7.991	0.445	5.0	7.6	6.564
H-1	24.7	7.7	481	8.8	3.1	7.1	22.2	7.466	0.257	4.6	5.9	0.440
H-2	26.4	8.6	313	10.3	7.7	19.3	35.3	2.151	0.165	7.4	1.4	0.366
H-3	27.2	7.5	1028	7.5	7.2	10.1	15.6	7.732	0.514	6.1	13.2	11.435
H-4	27.5	7.4	1162	7.0	5.6	9.7	12.0	7.175	0.575	5.9	20.2	11.871
H-5	27.6	7.8	1019	8.9	5.3	10.0	16.9	6.726	0.494	6.0	37.1	11.173
J-3	26.7	7.7	898	8.6	5.2	9.7	23.1	5.999	0.440	6.0	34.5	26.465
G-T	26.9	7.9	569	8.6	4.0	9.2	22.2	4.172	0.289	5.6	13.2	0.875

J-A	26.3	7.7	863	7.9	5.7	10.4	27.3	5.985	0.431	6.4	55.1	38.207

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