Supporting Information for

Occurrence and Attenuation of Pharmaceuticals and Their Transformation Products in Rivers Impacted by Sewage Treatment Plant

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Chemicals and material

The purity of all pharmaceuticals and their TPs was higher than 98%. The standard substances antipyrine (ATP), naproxen (NPX), carbamazepin 10,11-epoxide (CBZE), 1-naphthol (1-NT) were obtained from Sigma-Aldrich Trading Co., Ltd (Shanghai, China). 2-Hydroxy ibuprofen (2-OHIPF), carboxy ibuprofen (CIPF), 4-hydroxydiclofenac acid (4-OHDCF) were provided from Toronto Research Chemicals Inc (Toronto, Canada). Acetaminophen (ACE) was purchased from CND Isotopes (Pointe-Claire, Canada). Bezafibrate (BZB), 4-chlorobenzoic acid (4-CBA), ibuprofen (IPF), clofibric acid (CA), diclofenac acid (DCF), sulfadiazine (SDZ), sulfacetamide (STM), sulfamethoxazole (SMZ), N^4-acetyl Sulfamethoxazole (NAST), sulfathiazole (ST), carbamazepin (CBZ), phenacetin (PHE), nifedipine (NP) were purchased from J&K Chemical (Beijing, China). All surrogate standards except IPF-d_3 were purchased from CND Isotopes (Pointe-Claire, Canada) and IPF-d_3 was obtained from Toronto Research Chemicals Inc (Toronto, Canada). HPLC-grade methanol and acetonitrile were purchased from Merck Corporation (Darmstadt, Germany). Ultrapure water was produced by a water purification system (Sichuan Ulupure Ultra-pure Technology Company, China). The concentration of 1.0 g L^{-1} monomolecular stock solutions in methanol were spared and 10 mg L^{-1} working solutions of all

substances were also spared in methanol. All standard analyte solutions were stored at -20℃.

River characteristic

Physicochemical parameters of rivers such as dissolved oxygen, electrical conductivity, temperature and pH were monitored three times a week that using hand-held probes (Hach, USA) in the sampling process. Water flow velocity was measured by a model of LS1206B flow meter (Senlod, China) during the sampling course. And total suspended solids were collected from 0.45 μm glass fiber filter that water samples through.

Analytical methods

A 98:2 (v/v) water/methanol solution (phase A) and methanol solution (phase B), both containing 0.05% formic acid, were used as mobile phases for positive-ion mode. Mobile phases of 98:2 (v/v) water/methanol solution with 5 mM ammonium acetate (phase A) and acetonitrile (phase B) were used for negative ion mode. Detection of the target compounds was carried out on a mass spectrometer with ESI. ESI was used as ion source at a temperature of 150°C, and detection and quantification of analytes was done in multiple-reaction-monitoring mode. Sulfadiazine (SDZ), sulfacetamide (STM), sulfathiazole (ST), sulfamethoxazole (SMZ), N_4-acetylsulfamethoxazole (NAST), carbamazepine (CBZ), carbamazepine-10,11-epoxide (CBZE), phenacetin (PHE), acetaminophen (ACE), and antipyrine (ATP) were detected in positive-ion mode. Bezafibrate (BZB), 4-chlorobenzoic acid (4-CBA), ibuprofen (IPF), 2-hydroxyibuprofen (2-OHIPF), carboxyibuprofen (CIPF), clofibric acid (CA), diclofenac acid (DCF), 4-hydroxydiclofenac acid (4-OHDCF), naproxen (NPX), 1-naphthol (1-NT), and nifedipine (NP) were detected in negative-ion mode.

Table S1. The composition of mobile phase in two ion modes.

Time (min)	Composition of mobile phase (%)	
Positive ion mode	A	B
0	90	10
2.5	90	10
4	10	90
5	10	90
5.01	90	10
6	90	10
Negative ion mode	A	B
0	90	10
2.5	90	10
4	10	90
5	10	90
5.01	90	10
6	90	10

Table S2. The mass spectrometer optimization parameters of target compounds (including ionization mode, precursor ion, product ion, cone voltage, collision energy).

Compound	precursor ion (m/z)	product ion (m/z)	cone voltage (V)	collision energy (eV)	ionization mode
ACE-d_3	155.07	92.92	26	22	ESI+
ACE↟	152	110	40	12	ESI+
PHE	179.94	151.85	84	32	ESI+
ATP-d_3	192	58.92	40	28	ESI+
ATP	189	55.92	40	28	ESI+
SMZ-d_4	258.13	96.03	28	28	ESI+
STM↟	215	156	17	12	ESI+
SDZ	251	92	25	27	ESI+
SMZ	254	156	25	16	ESI+
ST	256	92	23	25	ESI+
NAST↟	296	134	24	16	ESI+
CBZ-d_{10}	246.97	175	30	42	ESI+
CBZ	236.97	178.87	30	34	ESI+
CBZE↟	253.07	236	28	12	ESI+
IPF-d_3	208.1	164	16	7	ESI-
IPF	205.1	161	16	7	ESI-
2-OHIPF↟	221.1	177	16	7	ESI-
CIPF↟	235.1	72.9	20	16	ESI-
DCF-d_4	298	254	22	15	ESI-
DCF	294	250	22	15	ESI-
4-OHDCF↟	312	230	30	32	ESI+
CA-d_4	217.2	131.01	20	18	ESI-
CA	213.13	127.01	24	16	ESI-
BZB-d_6	366.3	274.12	30	18	ESI-
BZB	360.13	274.06	32	20	ESI-
4-CBA↟	155.03	111	24	10	ESI-
NPX-d_3	232.1	173	22	16	ESI-
NPX	229.1	170	22	16	ESI-
NP	345.17	91.93	22	16	ESI-
1-NT	143.03	115	46	22	ESI-

↟Compounds marked with a five-pointed star are TPs.

Table S3. Recoveries of all target compounds added to tap water with concentrations of 10 ng L^{-1}, 100 ng L^{-1} respectively. Data are shown as mean ± standard deviation.

Compound	Recovery (%)		LOD[a]	LOQ[b]
	10 ng	100 ng		
ACE↟	90.42±5.5	97.12±11.2	0.24	0.81
PHE	103.83±2.4	115.79±10.4	0.04	0.12
ATP	105.35±4.1	102.72±2.0	0.02	0.08
BZB	95.42±1.8	97.23±5.9	0.01	0.04
4-CBA↟	96.60±1.9	98.26±4.5	0.09	0.30
CA	98.85±3.9	104.06±5.5	0.04	0.13
CBZ	125.62±4.5	125.43±3.1	0.01	0.05
CBZE↟	97.78±10.9	97.78±3.4	0.01	0.02
DCF	101.08±6.8	111.11±2.1	0.02	0.08
4-OHDCF↟	98.8±3.9	135.36±4.3	0.01	0.01
IPF	99.86±4.7	99.92±0.6	0.31	1.03
2-OHIPF↟	83.62±2.2	97.32±8.9	0.06	0.19
CIPF↟	91.07±1.9	92.85±13.6	0.33	1.08
NP	62.43±0.3	62.43±3.6	0.01	0.01
NPX	91.72±3.9	91.08±7.2	0.08	0.23
1-NT	65.45±8.0	64.0±9.3	0.03	0.09
SDZ	81.72±1.9	72.77±5.2	0.01	0.01
STM↟	68.6±5.3	92.13±0.9	0.01	0.03
ST	98.99±3.9	71.83±3.3	0.01	0.01
SMZ	90.14±4.8	97.44±6.5	0.01	0.01
NAST↟	103.61±11.6	107.56±7.3	0.02	0.06

[a]LOD refer to limits of detection (ng L^{-1}) that were determined as lowest concentration corresponding to the signal-to-noise (S/N) ratio of 3.
[b]LOQ refer to limits of quantification (ng L^{-1}) that were determined as lowest concentration corresponding to the signal-to-noise (S/N) ratio of 10.
↟Compounds marked with a five-pointed star are TPs.

Table S4. Concentrations (ng L^{-1}) of all detected compounds at all sampling sites in rivers. Data are shown as mean ± standard deviation.

STP	The north city (NC)					The science park (SP)					The east city (EC)			
River	Jinchuan (JC)		Yangtze (YZ)			Qinhuai (QH)					Yunliang (YL)			
Compound	N_1	N_2	N_3	N_4	N_5	S_1	S_2	S_3	S_4	S_5	E_1	E_2	E_3	E_4
ACE↑	1490±75	107±24	430±11	66.4±33	18.3±0.25	82±4.3	124±14	94±1.0	96±2.8	84±14.8	586±92	187±23	180±42	131±33
PHE	93.3±4.4	78.6±6.4	65±13.9	7.9±2.7	3.5±0.49	6.5±1.0	20.8±1.8	7.8±1.7	7.9±0.32	7.1±0.17	11.5±1.1	244±11	296±26	291±12
ATP	9.5±2.6	8.2±2.0	9.4±2.5	15.4±2.5	17.8±4.0	1.2±0.17	2.9±0.42	1.9±0.57	1.6±0.15	1.3±0.15	2.5±0.71	1.5±0.38	1.9±.042	1.7±0.49
BZB	9.2±0.75	9.5±0.47	9.4±1.3	5.0±0.48	4.2±0.41	3.1±1.1	11.9±2.7	5.6±1.6	2.9±0.19	3.0±0.46	1.6±0.25	2.5±0.49	2.47±0.59	2.2±0.62
4-CBA↑	13.9±2.8	7.8±0.51	17.9±2.3	21.5±1.3	25.2±1.1	9.9±1.8	12.3±2.4	8.2±1.5	7.35±0.71	11.3±3.5	23.4±5.6	10.7±1.95	13.6±1.5	15±2.8
CA	1.1±0.39	0.68±0.046	1.1±0.05	0.42±0.16	0.36±0.1	ND	ND	ND	ND	ND	0.8±0.26	1.35±0.78	1.13±0.5	1±0.29
CBZ	10.8±1.1	13.9±1.3	13.3±2.68	5.6±0.97	5.0±0.21	1.0±0.25	5.3±0.91	1.5±0.2	1.2±0.05	1.2±0.17	2.6±0.33	5.1±1.1	5.47±0.5	5.17±0.5
CBZE↑	363±30	544±35	448±34	63.2±9.2	55.5±5.4	1.2±0.14	8.4±1.1	3.6±1.4	1.9±0.42	1.5±0.28	5.3±1.2	5.4±0.59	5.36±0.6	5.3±0.53
DCF	183±16	374±27	287±20	38.7±5.4	38.8±5.7	ND	22.3±7.2	ND	ND	ND	19±3.9	22.6±8.6	26.7±2.1	25.1±1.8
4-OHDCF↑	4.2±0.88	10.3±1.2	7.3±0.74	1.1±0.49	0.55±0.21	ND	1.4±0.14	0.3±0.11	0.26±0.05	0.11±0.01	0.53±0.4	2.3±0.62	2.2±0.87	1.87±0.59
IPF	162±17	94.0±16	114±21	19.7±6.4	8.5±3.5	15±2.6	17.6±5.9	15.8±4.6	17.1±4.5	18.7±2.1	203±10	94±16	104±7.1	96±10
2-OHIPF↑	155±5.0	300±21	272±17	49.2±12.3	7.9±3.0	10.1±1.0	88.7±12	44.7±21	13.7±3.7	8.9±0.16	202±11	198±23	140±9.1	167±29
CIPF↑	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SDZ	3.8±0.5	4.9±0.92	2.5±0.32	2.3±0.57	2.7±0.11	3.4±1.7	18.9±3.7	9.5±1.6	3.75±0.81	2.8±0.54	1.1±0.64	0.43±0.32	1.0±0.7	1.07±0.6
STM↑	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SMZ	320±28	252±41	256±21	46±12	45±9.0	29±6.1	63.7±13	32.5±2.3	29.5±2.3	28.6±9.5	22.9±1.7	12.1±5.2	17.9±4.1	18.4±5.1
NAST↑	356±30	285±34	270±21	48±11	35±10	30.8±8.3	54.8±13.5	40.2±12	35.6±5.04	34.4±5.6	95±8.1	76±12	73.5±3.7	70±3.6
ST	2.8±1.1	1.8±0.334	1.6±0.8	0.51±0.11	0.5±0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-NT	8.4±1.7	ND	ND	ND	ND	1.8±0.4	ND	3.5±1.5	3.4±0.3	2.3±0.5	12.6	7.8	7.5	5
NPX	6.7±0.35	10±1.2	9.9±0.61	ND	ND	ND	7.4±1.6	ND	ND	ND	1.8±0.35	1.75±0.3	2.2±0.8	1.75±0.4
NP	ND	11.9±4.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND indicates no detectable or below LOQ.

↑Compounds marked with a five-pointed star are TPs.

Table S5. Details data of relevant analysis between the physical-chemical properties of compounds and attenuation rates by use of SPSS software.

		LogKow	YZ	QH	YL
LogKow	Pearson Correlation	1	0.459	-0.202	-0.130
	Sig. (2-tailed)		0.074	0.509	0.633
	N	17	16	13	16
YZ	Pearson Correlation	0.459	1	0.179	0.616*
	Sig. (2-tailed)	0.074		0.578	0.014
	N	16	16	12	15
QH	Pearson Correlation	-0.202	0.179	1	0.078
	Sig. (2-tailed)	0.509	0.578		0.801
	N	13	12	13	13
YL	Pearson Correlation	-0.130	0.616*	0.078	1
	Sig. (2-tailed)	0.633	0.014	0.801	
	N	16	15	13	16

*Correlation is significant at the 0.05 level (2-tailed).

Table S6. Attenuation values (%) from 11 pharmaceuticals and their TPs which were detected from samples collected by active and passive sampling. Data are shown as mean ± standard deviation.

River	Qinhuai (QH)		Yunliang (YL)	
Compound	Active	Passive	Active	Passive
ACE↟	3.4±4.3	7.8±11.6	47.6±24.2	89.1±4.9
PHE	22.8±16.2	25.8±3.2	18.6±3.1	19.5±22.1
BZB	45.5±25.6	N.A.	-82.3±23.4	-65.1±30.9
4-CBA↟	-91.2±28.9	N.A.	-73.4±2.7	30.5±11
CBZE↟	23.2±18.1	14.6±7.3	3.6±14.5	8.1±6.5
4OH-DCF↟	50.5±4.2	N.A.	19.8±11.9	22.5±7.3
IPF	-55±22.4	-39.3±2.8	-14.2±10.2	-6.2±6.6
2OH-IPF↟	53.4±13.7	N.A.	23.4±18.7	15.6±21.9
SDZ	59.6±7.5	48.3±12.1	-127±5.9	-82.3±8.5
SMZ	12.2±11.2	11.3±1.6	41.9±17.6	34±14.8
NAST↟	27.9±6.7	23.4±19.5	2.1±9.6	5.1±14.4

N.A indicates attenuation values cannot be obtained due to no detectable or concentration below LOQ.
↟Compounds marked with a five-pointed star are TPs.

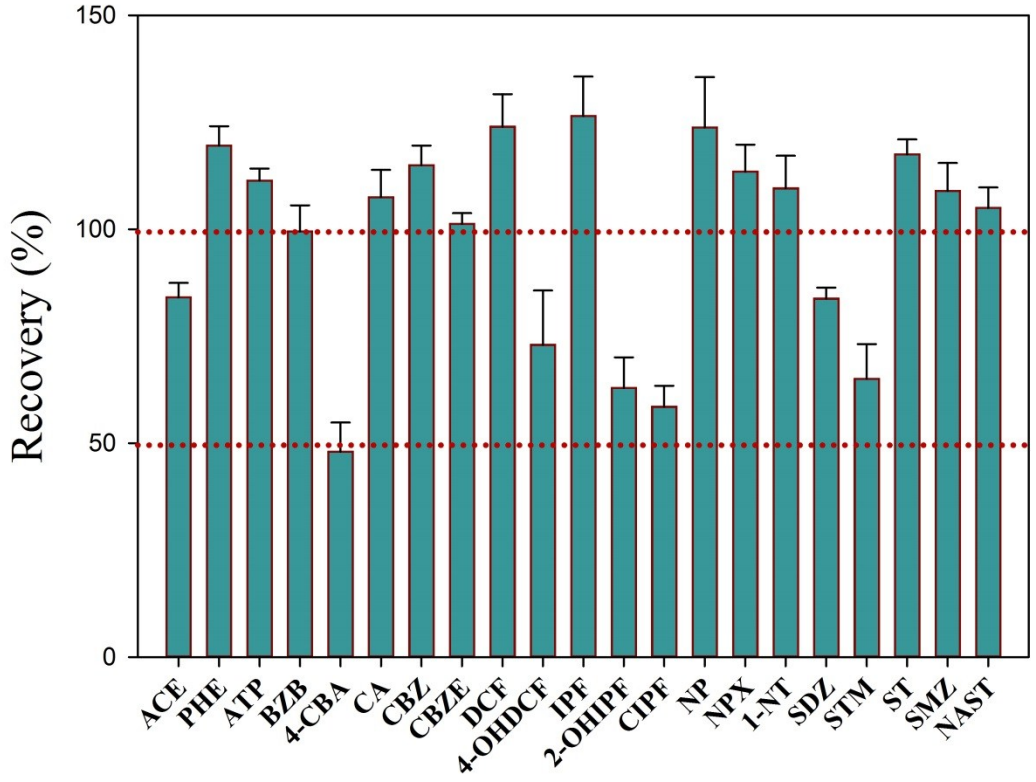

Figure S1. Recoveries of all target compounds spiked to river water with concentrations of 100 ng L^{-1}. Error bars represent the standard deviation.