

**Assessing the population equivalent and performance of wastewater treatment through the ratios of pharmaceuticals and personal products present in a river basin:**

**Application to the River Thames basin, UK**

Norihide Nakada<sup>1</sup>, Seiya Hanamoto<sup>1</sup>, Monika D. Jürgens<sup>2</sup>,

Andrew C. Johnson<sup>2</sup>, Michael J. Bowes<sup>2</sup>, Hiroaki Tanaka<sup>1</sup>

1: Research Center for Environmental Quality Management, Kyoto University, Japan

2: Centre for Ecology & Hydrology, UK

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Table S 1. Characteristics of sewage treatment plants (STPs) sampled in this study

STP ID	Biological treatment <sup>#</sup>	Human PE (1000)*	Ave. dry weather flow* (m <sup>3</sup> /d)	Water Usage (L/capita/d)	24-h composite sampling	
					Summer	Winter
A	AS	92	23,000	250	22/23 & 27/28 Aug. 2013	
B	TF	5.9	1,368	232	26/27 & 27/28 Jun. 2012 23/24 & 27/28 Aug. 2013 28/29 Aug. & 2/3 Sep. 2014 18/19 & 21/22 Aug. 2015	21/22 & 22/23 Jan. 2015
C	TF	11.3	2,406	213	26/27 & 27/28 Jun. 2012 26/27 & 27/28 Aug. 2013 28/29 Aug. & 1/2 Sep. 2014 18/19 & 21/22 Aug. 2015	21/22 & 22/23 Jan. 2015
D	AS	31.7	8,000	252	21/22 & 27/28 Aug. 2013 1/2 & 2/3 Sep. 2014 18/19 & 24/25 Aug. 2015	20/21 Jan. 2015
O	AS	162.8	38,000	233	25/26 & 27/28 Jun. 2012 21/22 & 26/27 Aug. 2013 27/28 Aug. & 2/3 Sep. 2014 18/19 & 20/21 Aug. 2015	20/21 & 22/23 Jan. 2015

<sup>#</sup> AS: activated sludge treatment, TF: trickling filter treatment

\* Database for the LF2000WQX model (Williams, Keller et al. 2009)

Table S2 Monitoring site and catchment characterization and sampling information.

Site no.*	River	Site information <sup>§</sup>			Sampling period [sampling method: G: grab, 24C: 24-h composite]														Flow rate (m <sup>3</sup> /s)#						
					2012		2013		2014			2015							2012		2013		2014		
		Catchment area (km <sup>2</sup> )	Sewage treatment works population equivalent	STP population equivalent density (PE/km <sup>2</sup> )	25 Jun.	27 Jun.	21 Aug.	26 Aug.	26 Aug.	27 Aug.	2 Sep.	19 Jan.	22 Jan.	26 Jan.	17 Aug.	23 Aug.	24 Aug.	25 Aug.	26 Aug.	25 Jun.	27 Jun.	21 Aug.	26 Aug.	26 Aug.	27 Aug.
1*	Thames	567	237,810	419					G	G	G		G	G			G	19.2	12.9	n.a.	0.6	3.4	4.4	0.8	
2	Cole	141	6620	47					G	G	G		G	G			G	3.0	1.2	0.2	0.2	1.1	0.5	0.4	
3	Coln	136	5440	40					G	G	G		G	G			G	2.6	2.6	0.9	0.9	1.1	1.1	1.0	
4	Leach	77	1540	20					G	G	G		G	G			G	0.7	0.7	0.1	0.1	0.2	0.2	0.1	
5*	Thames	1229	290,870	237					G	G	G		G	G			G	25.5	17.3	0.0	1.8	5.8	6.2	2.3	
6	Windrush	362	46,300	128					G	G	G		G	G			G	4.8	4.2	1.2	1.1	2.0	1.8	1.4	
7	Thames	1623	338,300	209					G	G	G		G	G			G	30.3	21.5	1.2	2.9	7.8	8.0	3.7	
8	Evenlode	427	40,100	94					G	G	G		G	G			G	5.4	4.1	0.9	0.9	1.7	1.8	1.0	
9	Cherwell	566	112,270	198					G	G	G		G	G			G	6.1	4.7	0.8	0.9	1.9	2.7	1.2	
10	Ray	290	46,020	159					G	G	G		G	G			G	5.1	3.6	0.2	0.1	0.8	0.8	0.4	
11*	Thames	n.a.	n.a.	n.a.	24C	24C	24C	24C		24C			G				G	48	34	3.0	4.8	12	14	6.5	
12	Littlemore Brook	n.a.	n.a.	n.a.	24C	24C	24C	24C		24C			G		24C		24C								
13*	Thames	n.a.	n.a.	n.a.	24C	24C	24C	24C		24C			G				G	24C	51	36	3.4	4.9	14	13	7.5
14	Ock	255	36,780	144					G				G				G	3.0	1.6	0.5	0.5	0.8	0.7	0.6	
15	Thame	532	153,710	289					G				G				G	7.9	7.1	0.6	0.7	1.0	1.4	1.0	
16*	Thames	4213	1,027,910	244					G				G				G	62	44	4.5	6.1	16	15	9.1	
17*	Thames	n.a.	n.a.	n.a.					G				G				G	62	44	4.5	6.1	16	15	9.1	
18	Pang	175	4990	29					G				G				G	0.6	0.6	0.5	0.5	0.7	0.7	0.6	
19*	Kennet	842	96,380	115					G				G				G	6.4	6.1	4.1	4.1	5.6	5.2	4.5	
20	Enborne	142	11,110	78					G				G				G	1.7	1.1	0.2	0.2	0.7	0.5	0.3	
21*	Thames	5790	1,586,110	274					G				G				G	83	62	13	14	25	31	20	
22	Loddon	n.a.	n.a.	n.a.					G				G				G	8.5	5.4	3.3	3.3	7.4	7.9	4.9	
23	Wye	134	82,300	613					G				G				G	0.7	0.6	1.0	1.0	0.7	0.8	0.9	
24	The Cut	63	103,600	1644					G				G				G	0.3	0.2	0.1	0.1	1.8	0.5	0.2	
25*	Thames	7192	2,661,370	370					G				G				G	93	68	17	18	35	40	26	

<sup>§</sup> Bowes et al. J. Hydro. 517 (2014) 1-12

<sup>#</sup> <http://nrfa.ceh.ac.uk/data/search>

\* flow rate was calculated from several points

Table S3. Frequency of detection (freq.) and the maximum (Max.) and averaged concentration (Ave.) in STP influent and effluent and river water samples.

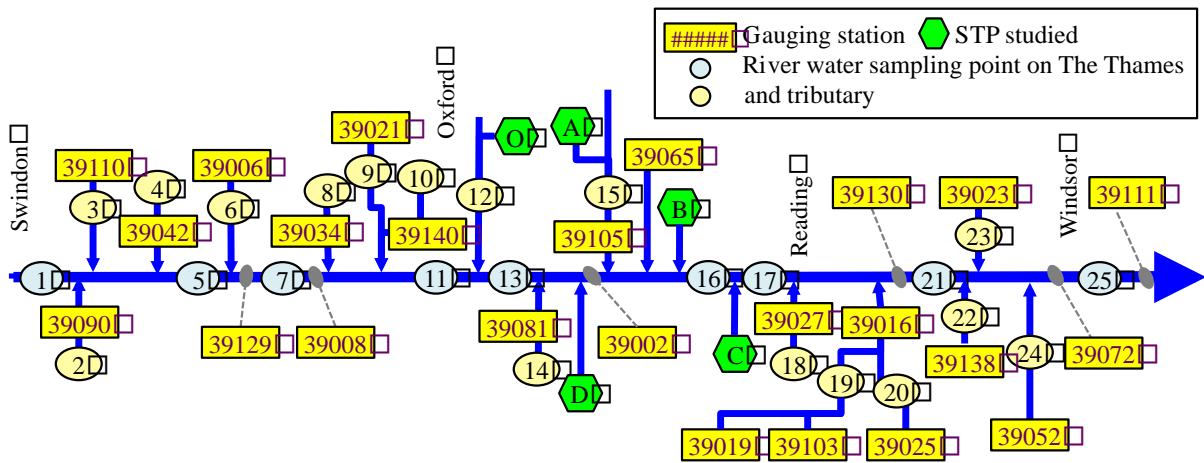
PPCPs	STP Influent (n = 35)			STP Effluent (n = 51)			River water (n = 232)		
	freq. (%)	Max. (ng/L)	Ave. (ng/L)	freq. (%)	Max. (ng/L)	Ave. (ng/L)	freq. (%)	Max. (ng/L)	Ave. (ng/L)
Acetaminophen	60	297,000	158,000	30	3,430	659	65	9,700	534
Antipyrine	0			9	5.7	3.4	9	2.4	1.0
Atenolol	100	2,940	1,720	95	564	344	88	457	60.0
Azithromycin	54	507	234	93	264	101	17	235	65.7
Bezafibrate	100	960	458	100	315	105	94	365	26.4
Caffeine	89	83,700	40,200	63	3,740	826	98	6,310	345
Carbamazepine	74	1,159	566	96	1,170	599	97	826	139
Chlortetracycline	0			0			0		
Clarithromycin	66	773	414	98	377	94	61	230	28.0
Clenbuterol	3	2.9	2.9	0			0.4	0.1	0.1
Clofibric acid	3	0.8	0.8	2	0.3	0.3	13	4.6	0.7
Crotamiton	97	550	202	100	455	166	91	258	48.0
Cyclophosphamide	29	40.9	9.2	54	10	3.0	53	8.4	1.2
DEET	94	4,210	1390	100	6,190	401	71	590	94.7
Diclofec	71	504	257	89	406	177	84	330	37.5
Diltiazem	80	206	105	91	107	43.7	77	83.6	9.0
Dipyridamole	80	1,430	661	89	285	95	28	113	28.3
Disopyramide	43	84.4	43.1	74	102	38.2	70	111	13.6
Ethenzamide	14	32.7	19.1	5	6.8	4.7	6	6.0	0.8
Fenoprofen	0			0			0.4	3.1	3.1
Furosemide	57	3074	1242	81	1050	530	35	566	132
Griseofulvin	6	10.7	9.0	44	12	7.1	27	14.4	3.6
Ifenprodil	0			0			0		
Indometacin	57	23.8	11.9	81	59	13	28	12.1	4.1
Isopropylantipyrine	9	1.3	0.9	16	22	3.8	12	1.8	0.3
Ketoprofen	74	135	54.0	65	71	11.7	15	25.3	6.1
Levofloxacin	34	119	44.4	67	47	6.9	10	8.0	2.9
Lincomycin	23	4.4	1.6	51	5.5	0.9	75	10.6	0.7
Mefemic acid	100	396	82.6	96	91	54	70	86.0	15.4
Metoprolol	97	68.1	31.3	100	37	24	53	38.3	8.9
Nalidixic acid	0			7	6.7	4.4	1	5.3	4.5
Naproxen	86	14,000	5890	91	1,760	495	89	683	49.1
Oxytetracycline	17	1,600	903	53	602	83	44	127	10.2
Pirenzepine	43	5.7	1.1	47	6.1	2.5	26	5.1	1.4
Primidone	71	226	102	88	235	84	85	85.0	17.9
Propranolol	83	326	136	89	291	90	84	130	15.7
Roxithromycin	20	9.1	3.9	65	9.1	4.7	36	7.7	1.8
Salbutamol	71	41.0	23.2	68	32	19	28	21.2	7.5
Sulfadimethoxine	3	2.6	2.6	9	4.6	3.7	4	2.0	0.8
Sulfamerazine	31	29.6	17.2	33	60	15	29	30.0	2.4
Sulfamethoxazole	94	356	142	95	227	76	88	146	23.1
Sulfamonomethoxine	11	2.5	1.2	9	1.2	0.4	17	0.7	0.2
Sulfapyridine	71	1,240	782	84	1,040	439	89	418	72.9
Sulfathiazole	6	7.2	7.2	4	4.9	4.6	6	3.6	0.8
Sulpiride	91	218	70	95	199	120	89	178	32.9
Tetracycline	17	3,030	1,390	53	239	80	37	87.3	10.8
Theophylline	83	4,840	2,850	96	380	76	99	315	26.5
Thiamphenicol	0			0			0.4	8.1	8.1
Tiamulin	11	2.3	1.5	9	2.9	0.9	16	0.5	0.05
Triclosan	26	740	442	28	514	209	3	137	130
Trimethoprim	89	1,580	551	95	500	313	91	427	57.7
Tylosin	3	8.9	8.9	7	3.9	2.3	9	14.5	2.1
2 quinoxalinecarboxylicacid	3	14	14	51	23	14	35	22.6	5.6

Abbreviations: pharmaceuticals and personal care products (PPCPs), sewage treatment plant (STP), and *N,N*-Diethyl-*m*-toluamide (DEET)

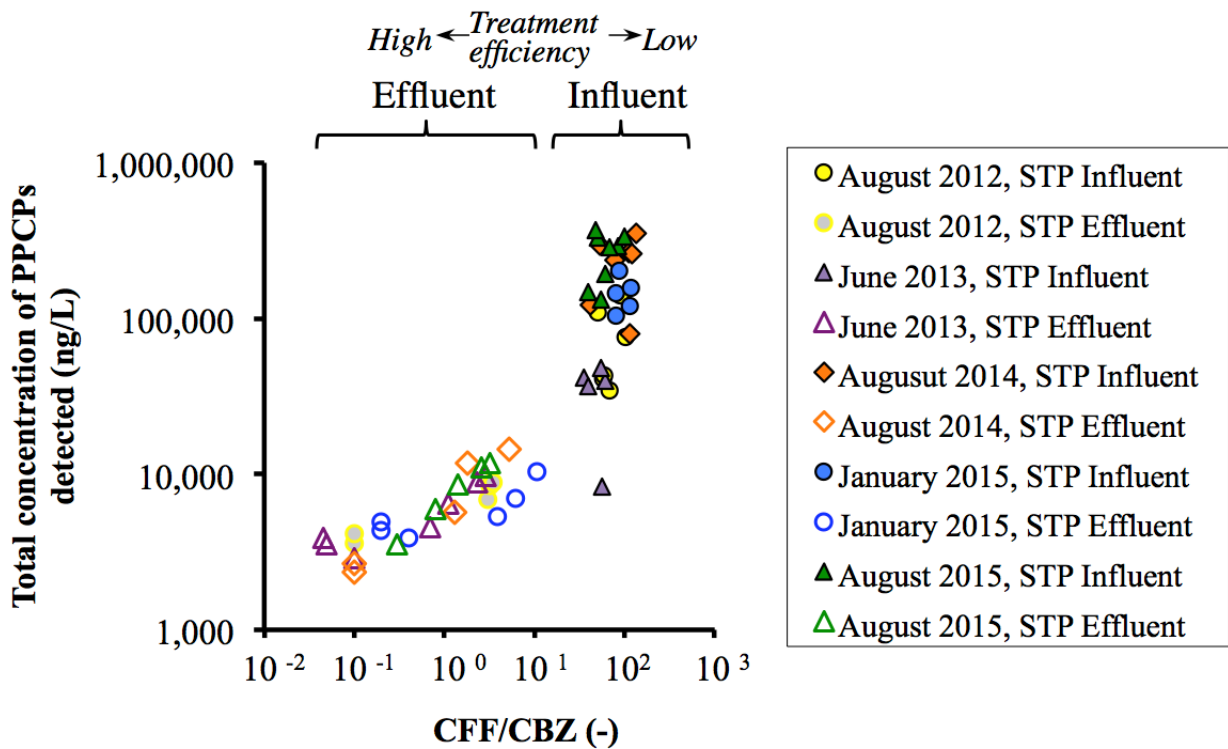
Table S4. Removal of Target PPCPs at AS and TF STPs in Summer and Winter

PPCP	AS STPs (3 STPs)						TF STP (2 STPs)					
	Summer			Winter			Summer			Winter		
	(data set = 12)			(data set = 2)			(data set = 14)			(data set = 2)		
	<i>no.</i>	Ave.	SD	<i>no.</i>	Ave.	SD	<i>no.</i>	Ave.	SD	<i>no.</i>	Ave.	SD
	<i>data</i>	(%)	(%)	<i>data</i>	(%)	(%)	<i>data</i>	(%)	(%)	<i>data</i>	(%)	(%)
Acetaminophen	2	100	0.04	1	100		7	99	1	2	99	0.4
Antipyrine	0			0			0			0		
Atenolol	10	87	10	2	58	5	14	83	3	2	70	4
Azithromycin	5	39	18	2	21	31	5	53	30	2	15	6
Bezafibrate	12	84	12	2	32	3	14	56	14	2	-28	80
Caffeine	7	100	0.05	2	100	0.2	14	95	2	2	91	4
Carbamazepine	8	-15	35	2	-2	43	10	-7	25	2	10	2
Chloramphenicol	0			0			0			0		
Chlortetracycline	0			0			0			0		
Ciprofloxacin	1	86		0			5	23	45	0		
Clarithromycin	7	87	8	2	50	7	8	37	29	2	30	21
Clenbuterol	0			0			0			0		
Clofibric acid	0			0			0			0		
Crotamiton	12	-29	32	2	-2	2	13	-8	49	2	13	21
Cyclophosphamide	4	-9	87	2	29	11	1	-241		0		
DEET	11	80	17	2	7	24	13	27	111	2	16	30
Diclofec	5	19	23	2	-25	38	10	18	15	2	-12	22
Diltiazem	9	60	9	1	19		11	49	8	1	22	
Dipyridamole	9	95	5	2	96	0.1	10	73	11	2	55	9
Disopyramide	10	-15	51	0			0			1	-20	
Enrofloxacin	0			0			0			0		
Ethenzamide	1	54		0			0			0		
Fenoprofen	0			0			0			0		
Furosemide	3	50	37	2	28	5	7	35	25	2	-4	26
Griseofulvin	2	16	26	0			0			0		
Ibuprofen	1	100		0			0			0		
Ifenprodil	0			0			0			0		
Indometacin	1	5		2	25	17	8	-15	42	1	27	
Isopropylantipyrine	0			2	-890	1,066	1	27		0		
Ketoprofen	5	84	10	2	36	8	6	69	26	2	47	8
Levofloxacin	2	67	1	1	71		2	-22	33	0		
Lincomycin	4	-39	179	0			2	38	5	0		
Mefemic acid	10	26	23	2	7	31	14	31	26	2	-5	20
Metoprolol	11	26	15	2	28	24	14	33	33	2	47	6
Nalidixic acid	0			0			0			0		
Naproxen	8	98	1	2	93	3	13	77	8	2	71	4
Norfloxacin	0			0			0			0		
Oxytetracycline	3	94	4	0			1	92		0		
Pirenzepine	2	37	7	1	-183		0			0		
Primidone	6	-18	39	2	-20	16	10	-20	38	2	-11	2
Propranolol	11	-10	56	0			9	13	28	2	9	26
Roxithromycin	5	17	48	1	16		1	-289		0		
Salbutamol	4	9	9	1	3		5	35	14	2	19	15
Sulfadimethoxine	0			0			1	13		0		
Sulfadimidine	0			0			0			0		
Sulfamerazine	3	84	8	2	-26	58	4	7	28	1	-1,150	
Sulfamethoxazole	10	42	23	2	32	19	13	20	40	2	-15	41
Sulfamonomethoxine	0			0			0			0		
Sulfapyridine	6	45	16	2	30	13	9	27	13	2	6	3
Sulfathiazole	0			0			0			0		
Sulpiride	12	-21	55	2	-44	11	11	-58	74	2	-20	113
Tetracycline	3	93	7	0			1	84		0		
Theophylline	7	99	0.4	2	99	0.1	14	93	2	2	83	3
Thiamphenicol	0			0			0			0		
Tiamulin	0			0			2	2	36	0		
Triclocarban	0			1	34		0			0		
Triclosan	2	59	25	1	48		1	73		1	9	
Trimethoprim	9	50	14	2	37	18	14	43	27	2	51	4
Tylosin	0			0			1	85		0		
2-quinoxalinecarboxylic acid	0			0			1	-32		0		

Abbreviations: pharmaceuticals and personal care products (PPCPs), sewage treatment plant (STP), average (Ave.), standard deviation (SD), and *N,N*-Diethyl-*m*-toluamide (DEET)

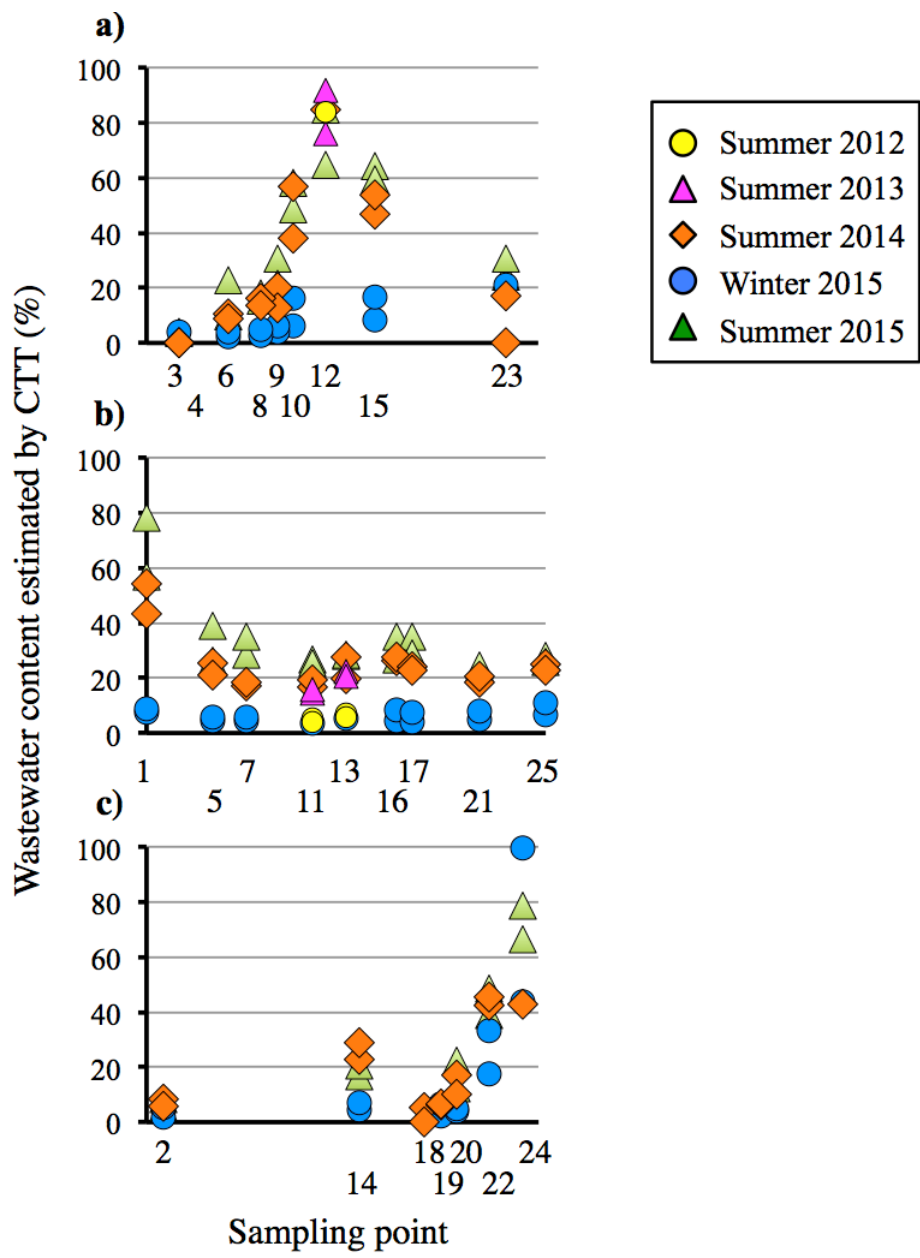


**Figure S1.** Relative location of sampling sites, STP, and gauging stations used for the calculation of flow rate at river water sampling points (approximate distances).



**Figure S2.** Relationship between CFF/CBZ and total PPCPs detected in influent and effluent samples.

Abbreviation: pharmaceuticals and personal care products (PPCPs), caffeine (CFF) and carbamazepine (CBZ)



**Figure S3.** Wastewater content estimated by crotamiton (CTT) in the northern tributaries (a), the main stem of the Thames, (b) and the southern tributaries, (c).

## References

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