Project Title: Occurrence Survey for Emerging Contaminants of Concern in Pennsylvania Tributaries of the Delaware River

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Executive Summary:

The goal of this research project is to increase our understanding of the occurrence of emerging contaminants of concern (ECCs) in surface waters by collecting and analyzing ambient water samples from a targeted area of the Delaware River Basin. Concentrations of ECCs are generally higher in urbanized and industrialized areas as was found in a previous study of the tidal Delaware River (report by DRBC; MacGillivray, 2012). The ten sampling sites in this study are in an area of southeastern Pennsylvania with numerous municipal and industrial discharges to surface water. The sampling locations are above and below potential source discharges for ECCs in watersheds draining to the Delaware River. Data and information obtained from this study advances our understanding of potential environmental exposures and the prevalence of emerging contaminants in relation to potential sources and builds on previous studies. Collectively, this information can provide environmental managers and other members of the environmental community and stakeholders with a greater awareness and better understanding of the presence of unregulated contaminants of concern in surface waters. This project can provide information needed for water quality planning and policy for emerging contaminants.

Research Report - Introduction

ECCs are unregulated substances that have entered the environment through human activities (e.g. from daily consumption, use and through municipal wastewater treatment plants). Currently, there is insufficient data on their occurrence in surface water to completely assess risks to human health or to the environment nor to support any water quality regulations. However, there is increasing public concern over potential human health and environmental implications. A previous multi-year survey of ECCs in the main stem of the tidal Delaware River sampled and analyzed ambient waters in 2007, 2008 and 2009. In those surveys pharmaceuticals and personal care products (PPCP), detected at concentrations of nanogram per liter (ng/L) in the river, were identified for additional focused study in surface waters. A recent study by the USGS (Philips, P., et. al. 2010) in New York detected certain pharmaceuticals downstream from manufacturing sources. Data from additional sampling sites in Pennsylvania tributaries to the Delaware River should expand our understanding of emerging contaminant sources and their potential risks to the environment. The sampling sites for this study are in urbanized and industrialized areas in stream segments designated for use as public water supplies after reasonable treatment, and for fish ingestion as well as aquatic life uses such as maintenance and propagation of resident fish and other aquatic life and wildlife protection. The possibility that ECCs are present in watersheds that sustain drinking water supplies or aquatic habitats validates the critical need to determine the extent and magnitude of occurrence. An important objective of this study is to provide more insightful and detailed information on both emerging contaminants and potential source contributions to surface waters in the Delaware River watershed. This information will further inform scientific and technical issues related to water quality and control policies involving emerging contaminants of concern. Additionally, results of this project can provide important additional information needed for water quality planning for emerging contaminants by the Delaware River Basin Commission, state agencies and municipalities.

Methodology

Sampling Procedures

The locations of proposed sampling sites were determined based on data from previous surveys of emerging contaminants in the surface water of the Delaware River Basin (Figure 1) and the identification of potential sources of pharmaceutical discharge to surface water from municipal and industrial discharges listed in the National Pollutant Discharge Elimination System Permit Compliance System (NPDES/PCS) linked to pharmaceutical manufacturing Standard Industrial Classification (SIC) codes. Sample site information is listed in Table 1 below and sample locations are depicted in Figure 2.

Analytical methods

The Temple University WET Center equivalent method (Temple University) to USEPA Method 1694 Pharmaceuticals and Personal Care Products in Water, Soil, Sediment, and Biosolids by HPLC/MS/MS, December 2007 was utilized for sample analysis.

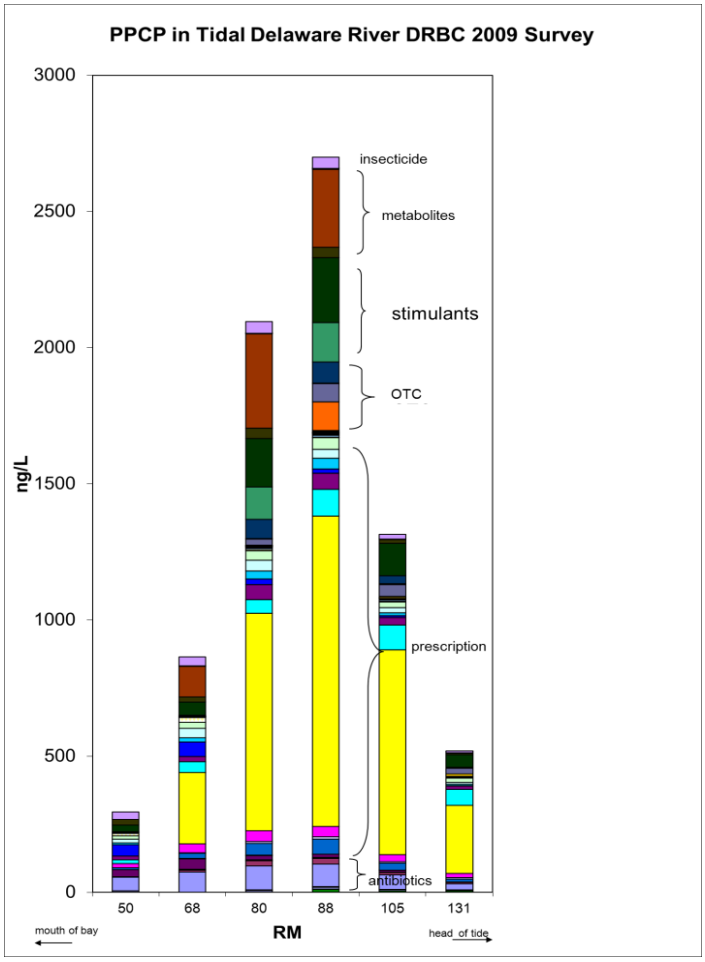

Figure 1. PPCP Occurrence in Delaware

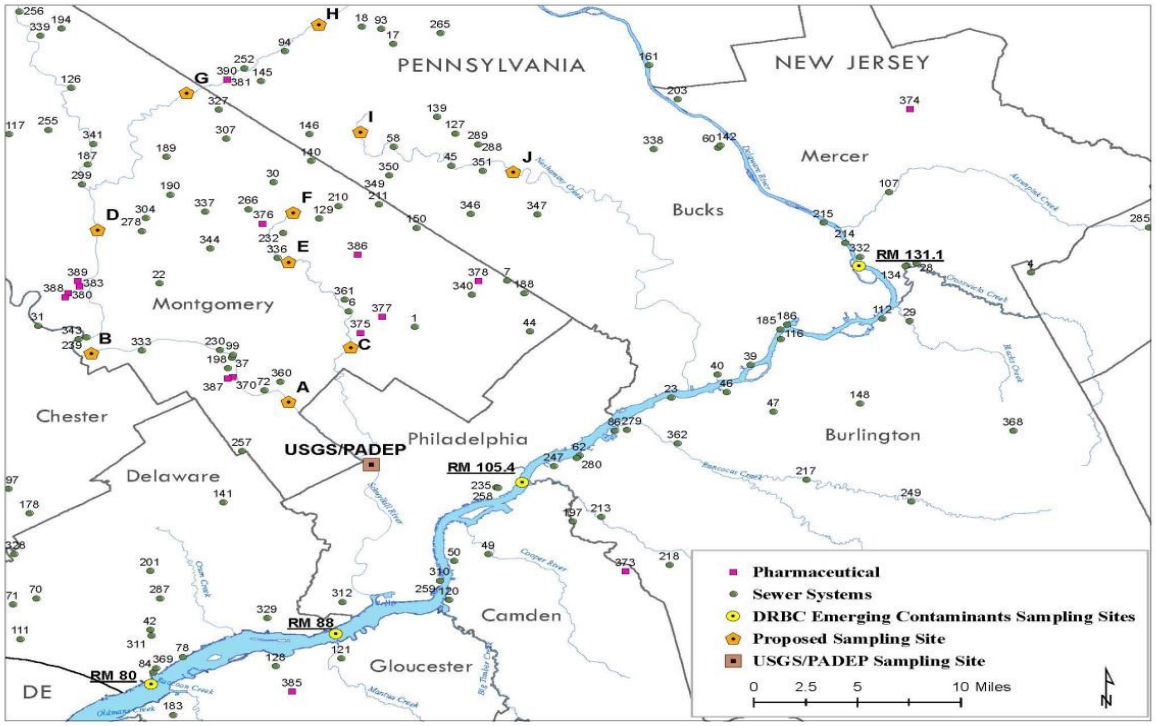

Figure 2. Sampling Sites Labels A-J

Table 1. Sampling Site Locations

Sample Site	Watershed	Agency	Sampling Coordinates		Location
			Latitude	Longitude	
I	North Branch Neshaminy Creek	DRBC	40.288436	-75.203283	Rt 152 Chalfont, PA
J	Neshaminy Creek	DRBC	40.269511	-75.074103	Mill Road West, Jamison PA
H	East Branch of Perkiomen Creek	DRBC	40.357747	-75.307885	North Main Street, Sellersville, PA
G	East Branch of Perkiomen Creek	DRBC	40.343008	-75.336636	Cathill Rd, Telford, PA
D	Perkiomen Creek	DRBC	40.209282	-75.449974	Bridge Rd (Rt 113 near intersection with Rt 29) , Perkiomen, PA
F	Wissahickon Creek	DRBC	40.146801	-75.226237	12 Morris Rd , Ambler, PA
C	Wissahickon Creek	DRBC	40.123833	-75.219861	544 Skippack Pike, Fort Washington Park, Fort Washington, PA
E	Wissahickon Creek	DRBC	40.084336	-75.227702	Germantown Bridge, Germantown Ave, Chestnut Hill, PA
B	Schuylkill River	DRBC	40.0706	-75.3096	Fayette Street Bridge, W. Conshohocken, PA
A	Schuylkill River	DRBC USGS/PA DEP	40.00840691	-75.19766536	Falls Bridge, East Falls, Philadelphia, PA

Samples were collected in duplicate sets at low flow conditions on three separate days over a spring, summer, and fall sampling period. Samples were collected by DRBC and Temple U. staff from ten locations in Pennsylvania tributaries of the Delaware River. Subsurface ambient water was sampled into 2.5 L amber glass bottles for analysis. Field blanks were collected. The samples were placed on ice in coolers to maintain a temperature of $4^{o}C \pm 2^{o}C$ and transported to Temple University for chemical analyses. In-field measurements of specific conductivity, specific conductivity, water temperature, dissolved oxygen, turbidity and pH were performed at all sites on each sample day and are listed in the result section.

Results

Water quality measurements taken during sampling are listed in the table below.

Table 2. In-field Water Quality Measurements

Sample	Date	Time	Temp °C	DO mg/L	DO % sat	Specific Conductivity µS/ml	pH	Turbidity NTU
EC-C-091113	09/11/13	1010	21.59	6.97	78.9	867.4	6.94	1.48
EC-I-091113	09/11/13	1115	23.16	7.6	88.6	230.2	6.7	4.19
EC-G-091113	09/11/13	1201	23.6	8.88	104.5	346.5	7.97	4.47
EC-E-091713	09/17/13	930	15.47	9.21	92.3	823	8.06	77
EC-F-091713	09/17/13	1030	14.95	9.64	95.8	991.8	7.98	0
EC-J-091713	09/17/13	1115	16.67	9.88	101.8	675.8	8.2	0
EC-H-091713	09/17/13	1212	17.7	8.97	94.3	227	7.83	3.8
EC-D-091713	09/17/13	1336	18.29	10.61	113	375	8.33	3.4
EC-B-091713	09/17/13	1427	20.68	9.76	109.1	529	8.21	4.4
EC-A-091713	09/17/13	1505	20.59	9.29	103.6	567.9	8.11	1.2
EC-E-100313	10/03/13	942	16.89	8.16	84.5	847.8	8.05	1.8
EC-C-100313	10/03/13	1005	17.76	8.9	93.7	907.1	7.77	0
EC-F-100313	10/03/13	1022	17.01	9.1	94.5	1053	7.93	0
EC-J-100313	10/03/13	1109	18.34	8.95	95.6	711.4	8.05	0
EC-I-100313	10/03/13	1130	18.94	8.03	86.5	258.7	7.61	10.8
EC-H-100313	10/03/13	1222	18.93	8.36	90.1	272.8	7.79	2.6
EC-G-100313	10/03/13	1243	19.5	9.86	108.2	404.9	8.08	0.2
EC-D-100313	10/03/13	1404	20.32	10.7	118.6	388.1	8.43	1
EC-B-100313	10/03/13	1448	21.32	9.63	108.9	572.4	8.36	46.6
EC-A-100313	10/03/13	1527	20.36	8.96	99.4	577.6	8.21	0.5
EC-E-042814	04/28/14	900	13.17	8.87	84.6	752.9	7.91	3.96
EC-C-042814	04/28/14	930	12.58	11.46	108	728.5	7.83	2.94
EC-F-042814	04/28/14	1000	14.81	12.02	118.9	679	8.13	1.42
EC-J-042814	04/28/14	1251	15.08	13.73	136.6	583.2	8.73	1.99
EC-I-042814	04/28/14	1355	16.79	11.65	120.2	384	8.34	7.73
EC-H-042814	04/28/14	1425	15.05	10.72	106.3	273.4	8.47	4.41
EC-G-042814	04/28/14	1442	18.08	13.24	140.6	408.6	9.43	2.07
EC-D-042814	04/28/14	1527	16.55	13.58	139	324.6	9	2.33
EC-B-042814	04/28/14	1618	15.96	10.16	103	368.5	7.95	5.47
EC-A-042814	04/28/14	1707	15.52	10.44	104.7	372.6	8.04	5.19

ECCs Monitor List

Ten compounds were selected based on previous identification as priority compounds for monitoring (MacGillivray, 2012). Five additional compounds were selected based on high frequencies of occurrence, high estimated volumes of use and usefulness as markers to potentially differentiate between industrial, medical and wastewater point sources. A complete list is included below.

Table 3. Priority ECC Compound List

Analyte	EC Type	Category	Description
triclocarban	PPCP	Personal care product	antibacterial, antifungal agent used in variety of products
carbamazepine	PPCP	Pharmaceutical	Prescription drug, central nervous system, anticonvulsant, mood-stabilizer, treatment of ADHD, WHO list of essential medicines
diltiazem	PPCP	Pharmaceutical	Prescription drug, cardiac disease, antihypertensive, antianginal, arrhythmia.
gemfibrozil	PPCP	Pharmaceutical	Prescription drug, fibrate class of lipid lowering agents
metformin	PPCP	Pharmaceutical	Prescription drug for diabetes treatment, biguanide class, WHO list of essential medicines.
guanylurea	PPCP	Pharmaceutical degradant	metformin biodegradation product produced in WWTPs
dehydronifedipine	PPCP	Pharmaceutical metabolite	Inactive metabolite of prescription cardiac drug nifedipine used for anti-anginal, antihypertensive and to treat premature labor, WHO list of essential medicines
thiabendazole	PPCP	Pharmaceutical/ fungicide	Prescription and veterinary drug as a parasiticide, also used in agricultural as a fungicide.
diphenhydramine	PPCP	Pharmaceutical/ OTC	Prescription and Over-the-counter drug, antihistamine used to treat allergies, non-prescription sleep aid.
ibuprofen	PPCP	Pharmaceutical/ OTC	Prescription and Over-the-counter drug, non-steroidal antiinflammatory drug used for pain, fever and inflammation, WHO list of essential medicines.
ranitidine	PPCP	Pharmaceutical/ OTC	Prescription and Over-the-counter drug for peptic ulcer and GERD treatments, WHO list of essential medicines.
clarithromycin	PPCP	Pharmaceutical/Antibiotic	Prescription drug, macrolide antibiotic, WHO list of essential medicines
trimethoprim	PPCP	Pharmaceutical/Antibiotic	Prescription drug, bacteriostatic antibiotic, frequently used in combination with sulfamethoxazole, WHO list of essential medicines
erythromycin	PPCP	Pharmaceutical/Antibiotic	Prescription drug, macrolide antibiotic, WHO list of essential medicines
sulfamethoxazole	PPCP	Pharmaceutical/Antibiotic	Prescription drug, sulfonamide bacteriostatic antibiotic, frequently used in combination with trimethoprim, WHO list of essential medicines

ECC Target Compound Detection Frequency

For this project 15 ECCs were monitored in surface water sample sets by HPLC-MS/MS resulting in 827 individual compound assays with 724 detections above the reporting limit. The overall detection frequency was 88%. Individual compound detection frequencies are listed in the table below.

Table 4. Detection Frequencies

ECC	Detection Frequency %	Comments
triclocarban	100	Priority compound
carbamazepine	97	Priority compound
diltiazem	75	Add'l compound, high volume
gemfibrozil	95	Priority compound
metformin	100	Priority compound
guanylurea	85	Add'l compound, Biodegradation of metformin, used as WWTP effluent marker
dehydronifedipine	90	Priority compound, metabolite used as WWTP effluent marker
thiabendazole	97	Priority compound
diphenhydramine	88	Add'l compound, high volume, OTC compound, emerging concern, frequently detected
ibuprofen	97	Priority compound
ranitidine	91	Add'l compound, OTC compound, high volume, persistent
clarithromycin	92	Priority compound
trimethoprim	88	Add'l compound used as co-drug with sulfamethoxazole, frequently detected
erythromycin	32	Usually detected as dehydroerythromycin, an environmental breakdown product; used erythromycin as marker for manufacturing discharges
sulfamethoxazole	90	Priority compound

Summary of Occurrence Data

As expected, high detection frequencies for the monitored compounds indicate a fairly consistent presence in sampled watersheds. Individual compound complete concentration data for the ten sample sites for 2013-2014 are listed in table 6 at the end of the results section. The concentration range and detection frequency for each of the monitored compounds is presented in table 5 below. The compounds are listed from highest to lowest maximum concentration. There is a wide concentration range for most of the compounds reflecting the variability in compound use, associated water use patterns as well as limitations of using grab samples to characterize surface waters. Metformin concentrations are the highest, consistent with previous Delaware River studies, as well as in other US water studies (Blair, 2013). Carbamazepine, diphenhydramine, triclocarban and guanylurea have the highest measured concentrations when summarizing the values across the sample sets by site.

Table 5. Detection Frequency and Measured Concentration Ranges

Analyte	Detection Frequency	Concentration Range in ng/L
metformin	100%	933 - 9258
guanylurea	85%	2.9 - 620
triclocarban	100%	6.3 - 265
carbamazepine	97%	2.3 - 243
thiabendazole	97%	0.1 - 191
ibuprofen	97%	3.7 - 152
ranitidine	91%	0.1 - 106
diphenhydramine	88%	0.6 - 101
gemfibrozil	95%	0.2 - 93
trimethoprim	88%	0.1 - 63
erythromycin	32%	0.2 - 58
sulfamethoxazole	90%	1 - 24
clarithromycin	92%	0.1 - 16
dehydronifedipine	90%	0.3 - 8.6
diltiazem	75%	0.4 - 8.2

A summary chart of the ECC concentrations by compound and by site is depicted in the figure below. The figure depicts the overall environmental loading by compound by summing the average of all measured concentrations by site. Metformin is depicted separately because of very high relative concentrations. Metformin, guanylurea, carbamazepine, triclocarban and ibuprofen have the highest relative loading. Concentration units are in ng/L.

Thiabendazole, ranitidine, guanylurea and ibuprofen show variable average concentrations by site. This could indicate the influence of intermittent point source contributions. Guanylurea, as a WWTP biodegradation product of metformin, is a useful indicator of relative WWTP effluent impacts to receiving waters. Thiabendazole and ranitidine concentrations are highest in the Wissahickon Creek samples indicating more localized point sources.

Figure 3. Sum of ECC average concentrations for each sampling site listed by compound.

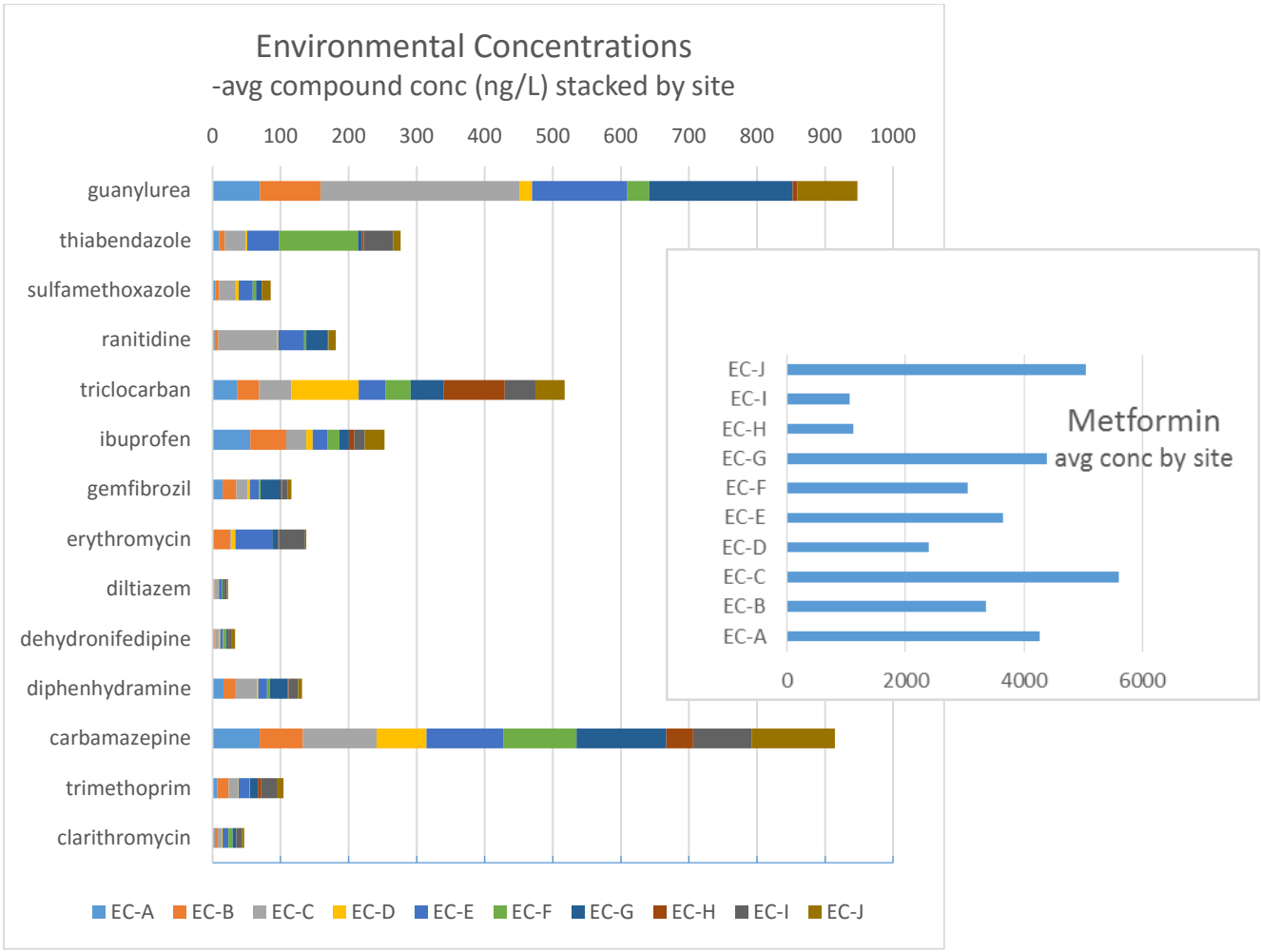

Table 6. Complete Data Sets by ECC Compound, Sample Set and Site (Concentrations are in ng/L).

ND – not detected; NA – not available

			Sampling Sites									
Analyte	Sample Set	Sample	EC-A	EC-B	EC-C	EC-D	EC-E	EC-F	EC-G	EC-H	EC-I	EC-J
Clarithromycin	1	1	3.4	6	0.1	0.8	11.2	14.8	4.8	0.8	15.6	2
	1	2	0.5	7	0.1	1.2	11.1	5.2	6.9	0.9	13.9	3.7
	2	1	4.6	6	10.8	1.6	8.5	6.6	3.4	0.8	0.2	2.6
	2	2	5.8	5.7	11.4	1.6	8.4	6.9	5.1	0.3	0.2	3.7
	3	1	1.7	2.1	5.5	ND	5.6	3.5	5.6	ND	ND	5.1
	3	2	2.2	2.2	6.1	1	5.3	2.8	4.5	ND	ND	5.7
trimethoprim	1	1	11.8	21.6	7.3	0.4	26	0.9	11.7	5.4	63.2	9.9
	1	2	9.2	32.7	7.9	1.5	24	0.8	10.4	12.5	48.1	17.6
	2	1	4.2	7.1	14.7	0.2	6.6	0.5	4.9	0.8	1	3.8
	2	2	5.6	23.7	15.8	0.2	6.3	0.4	6.4	0.5	0.1	3.7
	3	1	6	6.4	19.1	ND	16	ND	20.7	ND	14.7	14
	3	2	6.3	8.2	19.8	ND	16.4	ND	15.9	ND	11.6	ND
carbamazepine	1	1	71.5	62.1	40.9	63.1	112.9	138.9	133	NA	176.9	132.7
	1	2	74.5	58.6	45.9	60.7	129.4	118.4	140	NA	176	141.8
	2	1	128.1	125.4	243	120.2	190.7	183.4	143	78.4	73	208.2
	2	2	119.2	114.2	242.8	113.9	186.2	177.3	145.5	73.3	83.1	203.6
	3	1	11.6	11.4	34.3	34.9	27.4	15.7	118.5	3	2.3	25.3
	3	2	10.2	11.7	39.9	47.4	30.5	13.3	110.6	3.6	3.4	23
diphenhydramine	1	1	8.3	8.2	3.7	2.4	11.5	4	3.3	1.6	38.6	4
	1	2	14.4	8	4.8	0.6	10.4	NA	1.9	NA	37	4.1
	2	1	24.4	44.6	57.5	2.1	11.5	NA	13.1	0.8	2.7	NA
	2	2	36.7	28.8	101	NA	23.9	4	21.1	2.5	2.5	NA

	3	1	5.8	9.8	8.7	1.9	8.9	5	57.7	ND	1.8	6.3
	3	2	8.2	7.6	12	1.9	10.7	5.7	55.7	2	1	8.5
dehydronifedipine	1	1	1.3	1.3	NA	0.5	3.6	6.7	0.8	NA	6.2	4.1
	1	2	0.8	1.4	0.4	0.7	4.6	3.4	1	NA	8	6
	2	1	1.9	2.3	8.6	1.2	4.6	6.7	2.1	0.6	0.7	7.5
	2	2	2.1	1.6	8.4	1.2	4.7	5.8	1.3	0.6	0.3	6.7
	3	1	8.2	1.6	3.5	3	2.3	1.7	1.8	ND	ND	8.1
	3	2	2	ND	3.6	5.9	2.5	6.8	1	4.2	4.7	2.4
diltiazem	1	1	NA	0.9	NA	NA	2.2	0.4	NA	NA	6.6	0.5
	1	2	0.4	0.8	NA	NA	3.2	0.6	NA	NA	8	1.5
	2	1	1.4	1.2	4.5	0.5	1.5	0.9	2.4	0.4	0.4	2
	2	2	1.1	0.8	4.5	0.9	2.5	1.1	2.7	0.00	0.5	1.8
	3	1	1.3	2.2	7.4	ND	6.6	2.8	2.9	ND	ND	2.2
	3	2	2.9	1.8	8.2	ND	6.5	3.1	1.4	ND	ND	2.6
erythromycin	1	1	NA	23.5	NA	NA	52.1	NA	7.5	0.5	56.1	1.6
	1	2	1.5	21.3	1	6.4	55.6	NA	10.7	0.8	57.7	NA
	2	1	0.6	28.4	NA	NA	NA	NA	NA	NA	NA	NA
	2	2	NA	27.6	NA	NA	NA	NA	NA	3.4	0.2	NA
	3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
gemfibrozil	1	1	13.5	23.9	0.5	2.7	18.2	NA	1.3	0.4	26.8	2.4
	1	2	11.2	21.3	NA	2.7	17.9	NA	0.7	0.6	20.8	1.9
	2	1	18.4	21.2	30.5	1	13.9	0.8	5.5	3.2	0.8	3.5
	2	2	21.1	25.4	32.6	0.6	13.7	0.6	4.5	3.7	0.2	3.4
	3	1	12	13.8	9.6	6.8	8	4	93	1.4	1.3	10.1
	3	2	13.4	14.4	10.3	7.4	8.5	3.7	70.8	2	1.2	10.5
ibuprofen	1	1	99.5	151.7	4.7	13.9	18.1	7.3	6.1	16.1	28.3	62.9

	1	2	90.3	40	29.3	8	15.1	18.2	3.7	5.9	3.8	7.5
	2	1	38.3	34.2	32.2	5.2	15	NA	11.6	6.5	NA	30.1
	2	2	40.1	26	32.4	9.9	17.9	12.6	9.6	5.9	4.2	20.9
	3	1	33.9	35.6	29.7	9.2	29	33.2	26.9	6.8	22.7	27.8
	3	2	32.1	27.5	48.1	12.4	32.3	17.5	26.6	5.5	18.7	25.6
triclocarban	1	1	9.3	15.2	37.6	265.1	18.5	18.7	69.2	196.6	6.3	52
	1	2	10.5	30.8	38.7	108.2	71.8	11.7	35.7	120	35.8	63.7
	2	1	55.3	59.5	95.2	76.6	48.1	45.3	74.5	68.1	82	42.4
	2	2	87.7	22.3	52.5	84.6	47.9	87.4	53.7	89.9	79.6	44.1
	3	1	30.3	32	34	33.8	25.9	22.9	18.2	35.1	34.9	26.7
	3	2	27.5	29.7	26.6	24.2	26.9	35.4	39.3	27.5	31.9	30.7
metformin	1	1	4354	933	4370	1804	3536	2646	2747	1008	1066	3576
	1	2	3819	959	4316	1944	3708	2486	2840	1076	994	4349
	2	1	4056	5848	9242	NA	4207	4459	4193	NA	NA	7514
	2	2	4851	4447	9258	NA	4223	4406	4024	NA	NA	7672
	3	1	NA	NA	3095	3403	2955	2114	6507	1271	1009	3551
	3	2	NA	4642	3308	NA	3290	2181	6007	1141	1131	3640
ranitidine	1	1	1.8	4.1	86.4	0.8	42.7	1.6	8.7	NA	0.1	9.1
	1	2	1.9	3.4	90.4	NA	48.3	2	8.5	0.5	NA	11.7
	2	1	1.7	1.9	106	0.6	23.3	1.1	17	0.1	NA	8.7
	2	2	2.4	1.8	72.1	0.7	18.9	NA	14.8	0.1	NA	10.8
	3	1	5.5	11.7	83	2.2	42.5	5.3	70.3	1.3	ND	12.5
	3	2	5.1	9.7	83.3	3	50.6	6.2	71.5	1	NA	12.9
sulfamethoxazole	1	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	3	1	3.9	5.3	24	3.6	19.8	5.8	7.1	1	ND	12.7
	3	2	5.1	5.4	24	5.8	21.1	4.2	8.6	1.2	ND	12.1

thiabendazole	1	1	11	7.8	2.3	0.2	71.9	190.7	4.1	0.5	134.9	12.7
	1	2	4.6	14.2	0.5	3.5	87.8	150.2	4.5	2.5	113.1	11.5
	2	1	12.2	11	73.9	6	49.3	173.2	10.7	0.1	2.9	13.2
	2	2	15.8	11.1	74	5	59.6	155.9	10.3	1.1	3.6	17.9
	3	1	4	3.3	26	1.9	5.2	13.3	4.6	4.6	1.1	ND
	3	2	ND	2.7	5.7	1.3	5.5	12.5	1.8	6.1	1	2.1
guanylurea	1	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	1	130.7	158.9	620.1	NA	299.3	49.9	352.5	NA	NA	139.3
	2	2	127.2	173.7	458.5	33.7	168.7	NA	311.8	12.3	NA	144.9
	3	1	12	10.6	44	11.8	34.3	20.9	82.6	2.9	ND	31.6
	3	2	10.2	12	45.7	10	58.3	25.5	95.6	6.4	NA	36.5

Conclusions

By characterizing ECC concentration profiles by time and location, this study has expanded and advanced our understanding of the prevalence of emerging contaminants from different sources discharging into tributaries of the Delaware River watershed. It complements previous studies on the occurrence of emerging contaminants in ambient waters of Pennsylvania. Obtaining this environmental exposure research data will facilitate and inform initiatives aimed at assessing the occurrence of these emerging contaminants in order to begin to determine their fate, transport and any potential adverse effect implications within the Delaware River watershed. This information may provide environmental managers and other members of the environmental community and stakeholders with increased awareness of the presence of emerging contaminants of concern in surface waters.

Additional Research Indicated

Additional work is needed to classify and characterize contributions of different point sources for ECCs. Possible discrete sources within the Delaware River watershed are wastewater treatments plants, manufacturing site discharges, hospital and clinic wastewaters, long-term care facilities and other sources depending on local land uses. It is important to understand how the environmental loading of ECCs contributes to overall watershed stress and sustainability.

Citations

Blair, Benjamin D., et al. "Pharmaceuticals and personal care products found in the Great Lakes above concentrations of environmental concern."*Chemosphere* 93.9 (2013): 2116-2123.

Focazio, M J, W Kolpin and E T Furlong. 2004. Occurrence of Human Pharmaceuticals in Water Resources of the United States: A Review in Klaus Kummerer (ed) Pharmaceuticals in the Environment Sources, Fates, Effects and Risks, Springer, New York, New York

Kolpin, D W, E T Furlong, M T Meyer, E M Thurman, S D Zaugg, L B Barber, H T Buxton. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: a national reconnaissance. Environ. Sci. Technol., 36, 1202-1211

Loper, C.A., J.K. Crawford, K.L. Otto, R.L. Manning, M.T. Meyer, and E.T. Furlong. unpublished. Concentrations of selected pharmaceuticals and antibiotics in south-central Pennsylvania water, March through September 2006: U.S. Geological Survey Data Series 300 http://pubs.usgs.gov/ds/300/.

MacGillivray, A.R. unpublished. Contaminants of Emerging Concern in the Tidal Delaware River, Pilot Monitoring Survey, 2007 -2009. http://www.state.nj.us/drbc/library/documents/contaminants-ofemerging-concernJuly2012.pdf

Mack, P.M. unpublished. Emerging Contaminants in Metropolitan Chicago Rivers. Sierra Club-River Prairie Group Report , DuPage County, Illinois. http://illinois.sierraclub.org/RPG/reports/RPG_EmergContamReport2008.pdf.

Philips, P., et. al. 2010, Pharmaceutical Formulation Facilities as Sources of Opioids and Other Pharmaceuticals to Wastewater Treatment Plant Effluents, Environ. Sci. Technol. 2010, 44, 4910–4916.

Reif, Andrew G.; Crawford, J. Kent; Loper, Connie A.; Proctor,Arianne; Manning, Rhonda; Titler, Robert. unpublished. Occurrence of pharmaceuticals, hormones, and organic wastewater compounds in Pennsylvania waters, 2006-09. 2012, USGS Scientific Investigations Report: 2012-5106 http://pubs.er.usgs.gov/publication/sir20125106

Temple University WET Center Research Project Study "Evaluation of EPA analytical methods 1694 and 1698, and development of analytical methods for select emerging contaminants (ECs)".

Velicu, M and R Suri. 2009. Presence of steroid hormones and antibiotics in surface water of agricultural, suburban and mixed-use areas. Environ Monit Assess 154:349-359.

Appendix A

a. Staff

i. Number of individuals – 4 (partial)
ii. Number of full-time employees (as part of the grant) – 2 (partial)
iii. Number of full-time employees (as part of match) – 2 (partial)

b. Students Supported

i. Number of Undergraduate Students – 1 (partial)
ii. Number of Graduate Students – 1 (partial)
iii. Number of Ph.D. Students - none
iv. Degrees Awarded (please indicate level) -none

c. Outreach/Extension

i. Number of meetings, workshops, or conferences, and number of attendees
   - 1 workshop, 25 attendees
ii. Number of public or professional presentations, and number of attendees
   - 1 professional presentation, 35 attendees

Appendix B - Impact Statement

Title: Occurrence Survey for Emerging Contaminants of Concern in Pennsylvania Tributaries of the Delaware River

Relevance: ECCs are unregulated substances that enter the environment as a result of human activities. Currently, there is insufficient data on their occurrence in global surface waters to completely assess potential risks to human health or to the environment nor to support any water quality regulations. There is, however, increasing public concern over potential human health and ecological implications.

Response: With funding from a Pennsylvania Sea Grant, a watershed monitoring project was set up to characterize and understand the watershed surface water loading of prioritized ECCs and their resultant environmental exposure concentrations.

Results: By characterizing ECC concentration profiles by time and location this study has expanded and advanced our understanding of the prevalence of emerging contaminants from different sources discharging into tributaries of the Delaware River watershed. Obtaining these environmental occurrence research data will facilitate and inform research initiatives aimed at assessing the occurrence of these emerging contaminants in order to begin to determine their fate, transport and any potential adverse effect implications within the Delaware River watershed.

Project Partners: Delaware River Basin Commission