NJ Department of Environmental Protection
Pesticide Compliance & Enforcement
Pesticide Evaluation & Monitoring

GOLF COURSE RUN-OFF SURFACE WATER MONITORING 2017

Background

Routine monitoring of surface waters for pesticides is undertaken every year to proactively search out any possible pesticide discharge or residues to non-target water bodies in New Jersey. According to the Pesticide Evaluation & Monitoring Section (PEMS) pesticide use surveys, golf course pesticide use ranks third in New Jersey when compared to the other industries surveyed (agriculture and lawn care are first and second respectively). Golf courses reported 324,703 pounds of active ingredient applied in 2014. Monmouth and Somerset Counties reported the most golf course pesticide use in 2014, with each County reporting 12% of the total use. Based on the use data collected during the 2014 use survey, surface water downstream of golf courses was chosen as the focus for our 2017 spring/summer monitoring.

Field Sampling Procedures

Since Monmouth and Somerset Counties reported the most golf course pesticide use in 2014, these two Counites were targeted for our monitoring project. PEMS identified several golf courses in both Monmouth and Somerset Counties that are near surface water sources that could have potential for pesticide detections due to runoff. Potential surface water sampling sites were located using Google Maps street and satellite views. Nine sites were identified as flowing through, or in close proximity to, an active golf course. A site downstream of the golf course was chosen as the sampling location. The site locations are as follows:

County	Township
Monmouth	Colts Neck (3 sites)
	Marlboro
Somerset	Watchung (2 sites)
	Far Hills
	Bedminster
	Bridgewater

PEMS sampled the nine sites monthly from May to October. Two types of sampling equipment were used: polyurethane dipper and stainless-steel bomb sampler. The equipment used was determined by the geography of each site. A grab sample was collected at each site using either

the dipper or the bomb and transferred to a certified clean 950ml amber class bottle. Both the dipper and the bomb were thoroughly rinsed between samples using deionized water. Water quality measurements (dissolved oxygen (DO), turbidity, conductivity, pH and temperature) were also measured and recorded for each sample collected. The samples were held in chilled coolers during transport to the Pesticide Control Program (PCP) pesticide laboratory and immediately placed in refrigerators. Samples were submitted for gas chromatograph/mass spectrometer (GC/MS) pesticide scan analysis to identify any potential pesticide residues in the surface water samples.

Sample Results

Five different herbicides and three different fungicides were detected throughout the application season for a total of 29 detections across all sites during the five-month sampling period. Metolachlor was the most frequently detected herbicide (7 detections) with residues ranging from <0.2 to 1.1 µg/l. The highest residue of metolachlor detected is far below the 700 µg/l EPA Life-Time Health Advisory Level (HAL) (Table 1). However, the highest residue of metolachlor detected does exceed the chronic benchmark for aquatic invertebrates (1 µg/l) (Table 2).

Atrazine, another herbicide, was detected 3 times during the sampling period. The residues ranged from <0.2 to 4.5 µg/l. The highest residue of atrazine detected exceeds the acute toxicity benchmark for non-vascular plants (<1 µg/) (Table 2). The highest residue detected also nearly exceeds the chronic benchmark for fish (5 µg/l) and the acute benchmark for vascular plants (4.6 µg/l) (Table 2). In addition, the 4.5 µg/l residue also exceeds the EPA Drinking Water (DW) Standard of 3 µg/l (Table 1).

Residues of the fungicide chlorothalonil were detected twice during the sampling period. The residues ranged from 0.26 to 5.4 µg/l. The highest residue detected did not exceed the EPA's Drinking Water Equivalent Level (DWEL) of 500 µg/l (Table 1). However, this residue did exceed the acute and chronic benchmarks for fish and the acute and chronic benchmarks for invertebrates. It was also approaching the benchmark for non-vascular plants (Table 2).

Table 1 reflects the data acquired for each sampling site during the study. It includes the sample date, results of the analysis conducted and how those results correlate with US EPA or nationally established benchmarks. Any dashes or empty columns are associated with samples where pesticides were not detected during this study.

Table 2 details the five herbicides and three fungicides that were detected during the study as well as the highest results determined for that compound. These results are compared to criteria for aquatic life.

Table 1. 2017 Golf Course Surface Water

School Road, Marlboro, Monmouth County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/24/17	GC9-2017	SW1713	Dithiopyr	<0.2	--	--	100	--
			Metolachlor	<0.2	--	700	--	--
6/20/17	GC13-2017	SW1718	Metolachlor	<0.2	--	700	--	--
			Fluridone	2.1	--	--	100	--
7/27/17	GC27-2017	SW1735	Metolachlor	<0.2	--	700	--	--
			Fluridone	0.79	--	--	100	--
			Oxadiazon	ID	--	--	100	--
9/1/17	GC36-2017	SW1745	None	--	--	--	--	--
10/6/17	GC45-2017	SW1756	Metolachlor	<0.2	--	700	--	--

Merchants Way, Colts Necks, Monmouth County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/24/17	GC8-2017	SW1712	None	--	--	--	--	--
6/20/17	GC11-2017	SW1716	None	--	--	--	--	--
7/27/17	GC25-2017	SW1733	None	--	--	--	--	--
9/1/17	GC34-2017	SW1742	None	--	--	--	--	--
10/6/17	GC43-2017	SW1754	None	--	--	--	--	--

Artisan Place, Colts Neck, Monmouth County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/24/17	GC7-2017	SW1711	None	--	--	--	--	--
6/20/17	GC12-2017	SW1717	Metolachlor	<0.2	--	700	--	--
7/27/17	GC26-2017	SW1734	None	--	--	--	--	--
9/1/17	GC35-2017	SW1743	None	--	--	--	--	--
10/6/17	GC44-2017	SW1755	None	--	--	--	--	--

Table 1. 2017 Golf Course Surface Water (cont.)

Mercer Road, Colts Neck, Monmouth County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/24/17	GC6-2017	SW1710	None	--	--	--	--	--
6/20/17	GC10-2017	SW1715	None	--	--	--	--	--
7/27/17	GC24-2017	SW1732	None	--	--	--	--	--
9/1/17	GC33-2017	SW1741	None	--	--	--	--	--
10/6/17	GC42-2017	SW1753	None	--	--	--	--	--

River Road, Bedminster, Somerset County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/23/17	GC4-2017	SW1706	Atrazine	0.37	3	--	--	--
			Metolachlor	<0.2	--	700	--	--
6/22/17	GC17-2017	SW1723	Atrazine	4.5	3	--	--	--
			Metolachlor	1.1	--	700	--	--
			Metalaxyl	<0.2	--	--	100	--
7/26/17	GC22-2017	SW1729	Metalaxyl	0.26	--	--	100	--
			Dithiopyr	<0.2	--	--	100	--
9/1/17	GC31-2017	SW1739	None	--	--	--	--	--
10/5/17	GC40-2017	SW1751	None	--	--	--	--	--

Twin Brooks, Watchung, Somerset County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/23/17	GC1-2017	SW1703	Dithiopyr	<0.2	--	--	100	--
6/22/17	GC14-2017	SW1720	None	--	--	--	--	--
7/26/17	GC19-2017	SW1726	None	--	--	--	--	--
9/1/17	GC28-2017	SW1736	None	--	--	--	--	--
10/5/17	GC37-2017	SW1748	None	--	--	--	--	--

Table 1. 2017 Golf Course Surface Water (cont.)

Spook Hollow, Far Hills, Somerset County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/23/17	GC3-2017	SW1705	None	--	--	--	--	--
6/22/17	GC16-2017	SW1722	None	--	--	--	--	--
7/26/17	GC21-2017	SW1728	None	--	--	--	--	--
9/1/17	GC30-2017	SW1738	None	--	--	--	--	--
10/5/17	GC39-2017	SW1750	None	--	--	--	--	--

Somerset Cty, Watchung Somerset County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/23/17	GC2-2017	SW1704	None	--	--	--	--	--
6/22/17	GC15-2017	SW1721	Dithiopyr	<0.2	--	--	100	--
7/26/17	GC20-2017	SW1727	Iprodione	ID	--	--	100	--
			Metalaxyl	0.96	--	--	100	--
9/1/17	GC29-2017	SW1737	Chlorothalonil	5.4	--	--	--	--
10/5/17	GC38-2017	SW1749	None	--	--	--	--	500

Vorhees Lane, Bridgewater, Somerset County

Date Collected	Field ID	Lab ID	Detections	µg/l	EPA DW Standard (MCL)	Reference Levels (RL) µg/l EPA HAL (Life-time)	NJ Interim Generic GW Quality SOC	EPA DWEL
5/23/17	GC5-2017	SW1707	Dithiopyr	0.47	--	--	100	--
6/22/17	GC18-2017	SW1724	Dithiopyr	0.2	--	--	100	--
			Atrazine	<0.2	3	--	--	--
			Iprodione	ID	--	--	100	--
7/26/17	GC23-2017	SW1730	Iprodione	ID	--	--	100	--
			Chlorothalonil	0.26	--	--	--	500
9/1/17	GC32-2017	SW1740	Iprodione	ID	--	--	100	--
10/5/17	GC41-2017	SW1752	None	--	--	--	--	--

ID = Analyte was qualitatively identified using a pesticide mass spectral library but was not quantified with a reference standard.

MCL = Maximum Contaminant Level
GW = Ground Water
SOC = Synthetic Organic Compound

The values in Table 1 were extracted directly from the following website:
https://www.epa.gov/dwstandardsregulations/2018-drinking-water-standards-and-advisory-tables

Table 2. Freshwater Aquatic Life Benchmarks

	Highest Conc. Detected (µg/l)	Fish Acute[1] Level (µg/l)	Fish Chronic[2] Level (µg/l)	Invertebrates Acute[3] Level (µg/l)	Invertebrates Chronic[4] Level (µg/l)	Plants Non-Vascular Acute[5] Level (µg/l)	Plants Vascular Acute[6] Level (µg/l)
Dithiopyr	0.47	235	56	>850	81	20	-
Atrazine	4.5	2650	5	360	60	**<1**	4.6
Metolachlor	1.1	1900	30	550	**1**	80	21
Metalaxyl	0.96	65000	9100	14000	100	140000	92000
Fluridone	2.1	2550	480	2600	-	-	-
Oxadiazon	Identified	600	33	1090	33	5.2	41
Iprodione	Identified	-	260	120	-	>130	>12640
Chlorothalonil	5.4	**5.25**	**3**	**1.8**	**0.6**	6.8	630

[1] Benchmark = Toxicity value x LOC. For acute fish, toxicity value is generally the lowest 96-hour LC50 in a standardized test (usually with rainbow trout, fathead minnow, or bluegill), and the LOC is 0.5.

[2] Benchmark = Toxicity value x LOC. For chronic fish, toxicity value is usually the lowest NOEAC from a life-cycle or early life stage test (usually with rainbow trout or fathead minnow), and the LOC is 1.

[3] Benchmark = Toxicity value x LOC. For acute invertebrate, toxicity value is usually the lowest 48- or 96-hour EC50 or LC50 in a standardized test (usually with midge, scud, or daphnids), and the LOC is 0.5.

[4] Benchmark = Toxicity value x LOC. For chronic invertebrates, toxicity value is usually the lowest NOAEC from a life-cycle test with invertebrates (usually with midge, scud, or daphnids), and the LOC is 1.

[5] Benchmark = Toxicity value x LOC. For acute nonvascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with green algae or diatoms), and the LOC is 1.

[6] Benchmark = Toxicity value x LOC. For acute vascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with duckweed) and the LOC is 1.

NOAEC = no-observed-adverse-effects concentration
LOC = level of concern
EC50 = 50 percent effect concentration
LC50 = 50 percent lethal concentration

The reference values in Table 2 were extracted directly from the following website: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/aquatic-life-benchmarks-pesticide-registration.

Summary

The water sampled during this project was surface water, not ground water. While the guidelines referenced in Table 1 apply to drinking water and ground water, they provide an additional reference point when conducting an overall aquatic assessment. The aquatic life benchmarks provided in Table 2 provide the best assessment tool for this surface water project. Aquatic life benchmarks were established by the EPA's Office of Pesticide Programs and Office of Water. Comparing a measured concentration of a pesticide in water with an aquatic life benchmark can be helpful when interpreting monitoring data, and to identify and prioritize sites and pesticides that may require further investigation. Several residue detections exceeded acute and chronic aquatic benchmarks for fish, invertebrates and plants. These residues raise concern regarding the health of the aquatic life in the stream where the detections occurred, most notably because invertebrates are at the bottom of the food web. Low level pesticide detections in surface water may not have a direct impact on human health, but impacts to aquatic microorganisms can have effects on higher level consumers. A full stream health assessment would help identify impacts from these detections. PEM recommends that aquatic life benchmarks continue to be part of the data assessment tools used for future surface water monitoring projects.

In addition, PEMS will share our results with the Bureau of Freshwater and Biological Monitoring. This Bureau conducts monitoring of aquatic macroinvertebrates in streams throughout NJ as part of their Ambient Biomonitoring Network. We would compare our sample results with their data to see if the pesticide residues detected might be causing impairment to the stream organisms.

Citations

"Standard Operation Procedure: Collection of Pesticide Samples." NJDEP, Pesticide Control Program. (2007).

USEPA. Aquatic Life Benchmarks for Pesticide Registration. Retrieved from https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/aquatic-life-benchmarks-pesticide-registration.

USEPA. 2018 Drinking Water Standards and Advisory Tables. Retrieved from https://www.epa.gov/dwstandardsregulations/2018-drinking-water-standards-and-advisory-tables.