Human Markers Present in Torch Lake Groundwater Samples Collected in 2016

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Background

Since the 1980s, Torch Lake in Antrim County, Michigan has been undergoing a change.

The change is occurring on the bottom of the lake, where the cobble bottom is being covered. The grain and color of each rock on the bottom of the lake to a depth of 15-20 feet was easily identified until the 1970s. While the renowned clarity of the lake water has not changed, the rocks are slowly getting covered by an ivory colored coating. In 2014, this ivory coating turned into a golden-brown color.

Changes in algae mean there are changes in the lake, according to Dr. R. Jan Stevenson, of Michigan State University.

In the summer of 2015, Dr. Rex Lowe, Dr. Pat Kociolek and Dr. Jan Stevenson, supported by volunteers from The Three Lakes Association, determined the golden-brown coating on the bottom of the lake-both rocks and sand--was composed of diatoms. Diatoms are microscopic aquatic plants or algae. Algae require sunlight and nutrients to grow. Algae grow better when more nutrients like phosphorus and nitrogen are available.

Nutrient concentrations are typically low in Torch Lake based on yearly deep basin sampling from 1990s to the present - phosphorus less than 6 µg/L and nitrogen 400-500 µg/L (Watershedcouncil.org.) Sources of these nutrients include stormwater run-off, erosion, decaying leaf and aquatic plant matter, the atmosphere, and groundwater.

Groundwater flows into Torch Lake at variable rates and locations. The size of the groundwater watershed is unknown and definitive studies of flow rates and directions around Torch Lake have not been performed. Based on observations of shoreline seeps, artesian wells and a past study of phosphorus loading, it is assumed at the 4 sites herein reported groundwater flows into and not away from the lake.

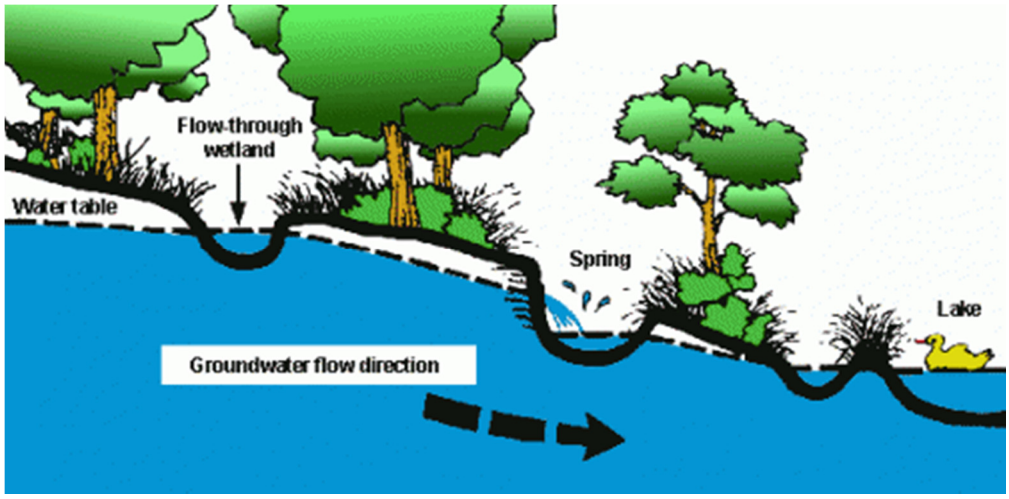

Image 1. Credit Oregon State University

Septic drainfields are required by the current Health code to be installed at least 4 feet above the water table in Antrim County in northwestern Michigan. However, water table levels can increase or decrease in response to rainfall and lake levels, thereby affecting the true vertical distance between the water table and drainfield. Whether from water level changes or from usage saturated septic drainfields act like wet sponges. When they are full, they leak. Drainfields can be a source of nutrients from human waste to groundwater.

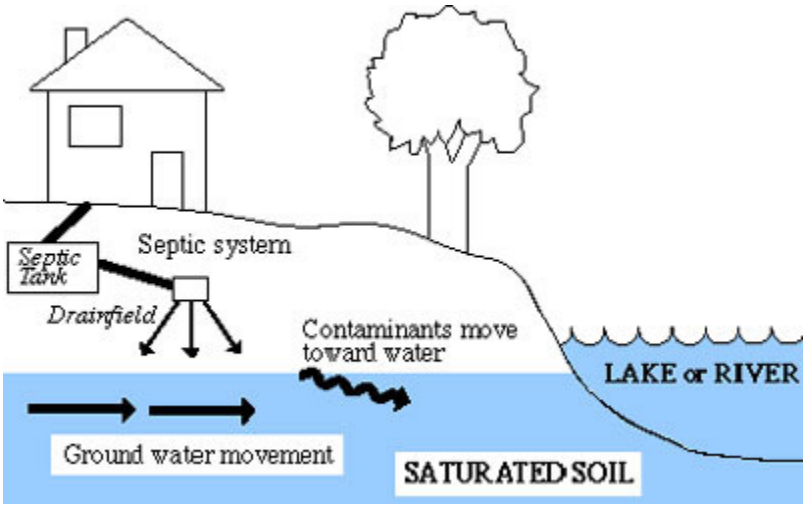

Image 2: Credit University of Minnesota Extension

Methods

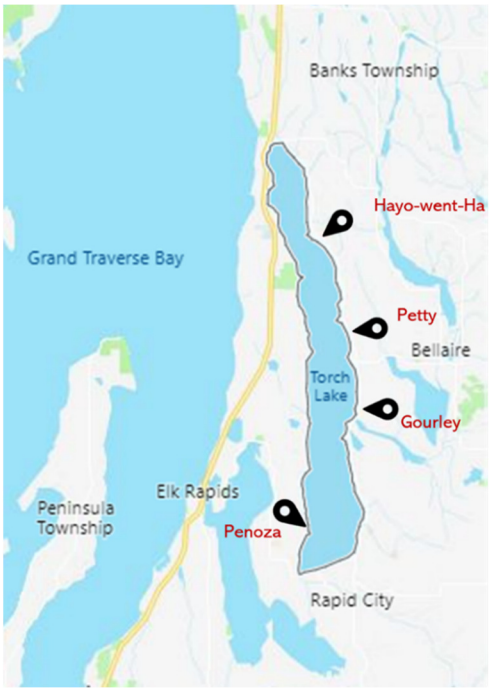

Image 3: 4 Sampling Sites on Torch Lake, Antrim County

To determine if drainfields could be the source of nutrients feeding the diatom growth, the Three Lakes Association collected and analyzed groundwater samples from 4 sites on Torch Lake.

Site	N Latitude	W Longitude
Petty	44.99142	85.28773
Hayo-went-Ha	44.99150	85.28790
Gourley	44.94500	85.28130
Penoza	44.87630	85.32100

Table 1. Global Positioning System coordinates for 4 sites on Torch Lake. Three sites are located on the eastern shore. One site, Penoza, is located on the western shore.

Samples were collected each month during the summer of 2016 from approximately 2 ft below the lake floor by gentle suction through permanent piezometers placed in 2-4 ft water depth during the previous summer at 3 sites along the eastern shoreline and from a temporary piezometer at one site (Penoza site) on the southwest shoreline.

As phosphorus and nitrogen, two primary nutrients, are not readily differentiated as to source - human, other animals, soil, or chemical fertilizer, it could not be determined how much may come from septic drainfields. Compounds not naturally present in water like caffeine, DEET, triclosan and benzothiazole (BTH) are considered human markers. These compounds act as proxies for nutrients. The presence of human markers in groundwater would indicate that some materials in septic effluents from drainfields are reaching the groundwater flowing into the lake.

Caffeine is a chemical found in coffee, tea, colas, chocolate and other products. It is present in seeds, nuts, and leaves from about 60 plants native to Africa, East Asia and South America. It is the most widely consumed legal psychoactive drug. A cup of coffee contains 80-175 mg of caffeine.

DEET or diethyltoluaminde is the active ingredient in insect repellants. It is a manmade compound developed in 1944 for use by the U.S. Army. In 1957, it became available to the public. It is toxic to zooplankton and freshwater fish.

Triclosan is an active ingredient to prevent bacterial contamination. It is used in antibacterial soaps, body washes, toothpastes and some cosmetics. It is a manmade compound developed in the 1960s. In September 2017, the FDA prohibited sale of consumer antiseptic washes containing triclosan due to lack of evidence showing it performs better than soap and water. Triclosan is an endocrine disruptor and is toxic to aquatic bacteria and some types of algae.

BTH or benzothiazole is a compound found in plastics used for drinking water household plumbing. It may leach out of pipes, particularly those used for hot water, and be carried along with wastewater.

Analysis of groundwater samples for the above compounds was performed at the University of Michigan Biological Station Laboratory, Pellston, Michigan using a modified EPA Method 530 (semi-volatiles by solid phase extraction/GC-MS detection). The minimum detectable level for caffeine, DEET, triclosan, and BTH was 0.0009 ug/L.

Results

The Petty site is located on the eastern shore of Torch Lake. Human marker concentrations for groundwater samples collected from the Petty site are presented in Table 2.

Date	Caffeine µg/L	DEET µg/L	Triclosan µg/L	BTH µg/L
6/21/2016	0.0024	4.28218	0.18031	0.49735
7/27/2016	0.1166	66.89850	0.07931	0.15802
8/25/2016	BDL	1.13062	0.03093	0.01913
9/19/2016	0.02306	5.44971	0.44629	0.13131

Table 2. Concentration of 4 human marker compounds in groundwater samples collected from permanent piezometer each month during summer off the Petty site. BDL means Below Detectable Level of 0.0009 µg/L.

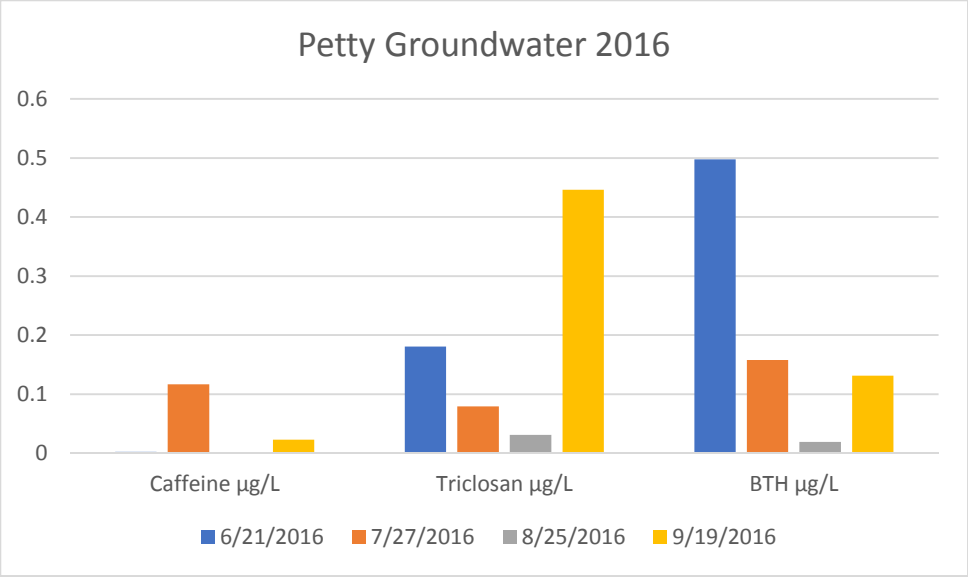

Figure 1. Caffeine, triclosan and BTH concentrations in groundwater samples collected from Petty site. For graphing purposes, Below Detectable Level, BDL was treated as 0.

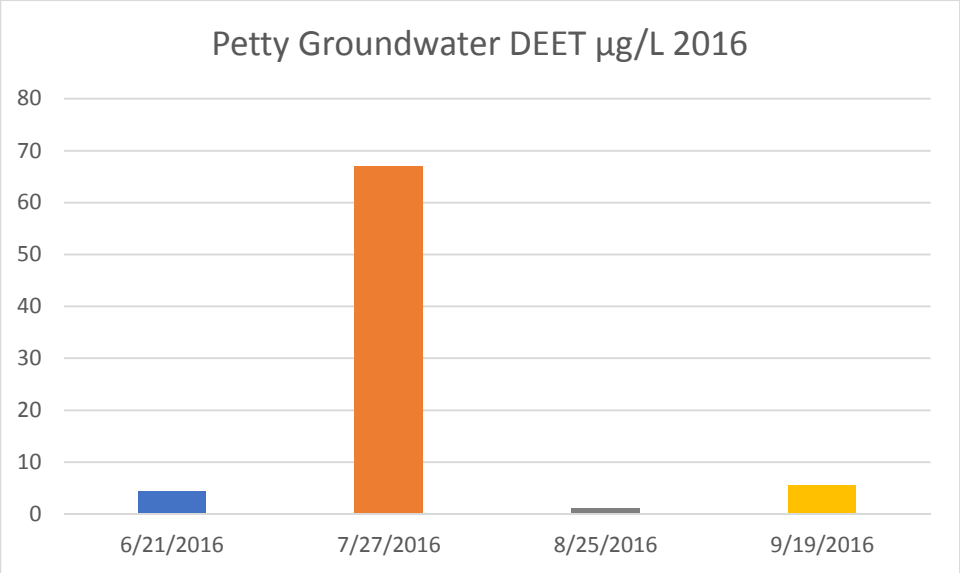

Figure 2. DEET concentration in groundwater samples collected from Petty site.

All 4 human markers were present in 3 of 4 water samples (Figures 1 and 2). In the August groundwater sample, caffeine concentration was below detectable level. Caffeine and DEET concentrations in groundwater samples peaked in July. The high DEET concentration in July (66.9 ug/L) was 13x higher than the next highest concentration (5.45 ug/L); it is not known whether DEET may have been applied out of doors to reduce the mosquito population .

Triclosan concentration in groundwater samples from this site peaked in September while BTH concentration peaked in June.

The Hayo-went-Ha site is located on the northeast shore of Torch Lake. Human marker concentrations for groundwater samples collected from the Hayo-went-Ha site are presented in Table 3.

Date	Caffeine µg/L	DEET µg/L	Triclosan µg/L	BTH µg/L
6/21/2016	0.00096	0.28695	0.04199	0.25898
7/27/2016	0.19159	1.17255	0.18301	0.0956
8/25/2016	na	na	na	0.8487
9/19/2016	BDL	0.95766	BDL	0.04515

Table 3. Concentration of 4 human marker compounds in groundwater samples collected from permanent piezometer each month during summer Hayo-went-Ha site. NA means the sample was not analyzed for the compound. BDL means Below Detectable Level of 0.0009 µg/L.

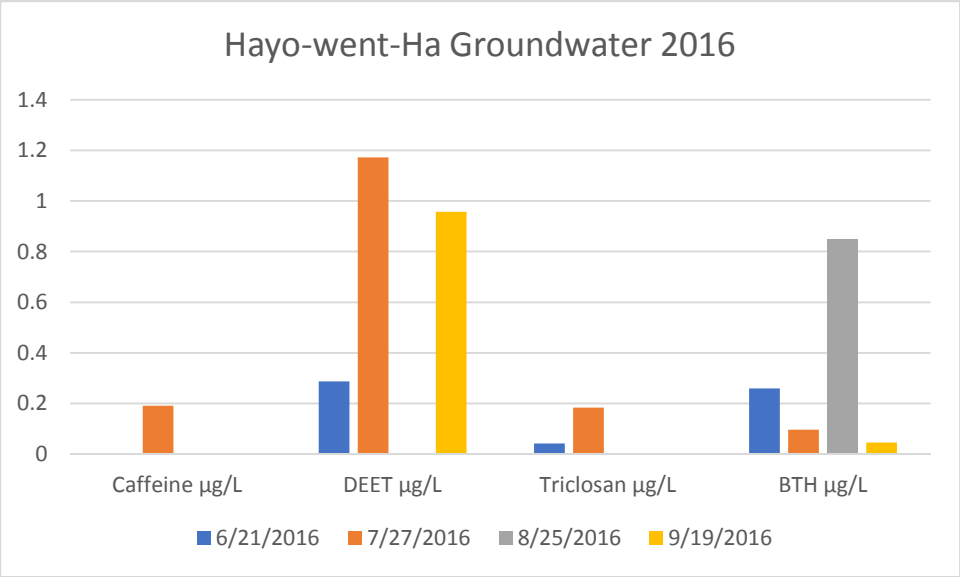

Figure 3. Caffeine, DEET, triclosan and BTH concentrations in groundwater samples collected from a permanent piezometer off Hayo-went-Ha site during June, July and September.

The August groundwater sample was not analyzed for caffeine, DEET or triclosan. The caffeine and triclosan concentrations in the September groundwater sample were below detectable levels; for graphing purposes, a value of zero was used for these findings.

Two of the 4 groundwater samples (June and July) collected from the Hayo-went-Ha site contained all 4 human markers (Figure 3). One groundwater sample (September) contained 2 human markers and one groundwater sample (August) contained BTH, the only compound for which analysis was performed on that sample.

Caffeine, DEET and triclosan concentrations in groundwater samples from this site peaked in July while BTH concentration peaked in August.

The Gourley site is located on the eastern side of Torch Lake, just north of the Clam River outflow. Human marker concentrations for groundwater samples collected from the Gourley site are presented in Table 4.

Date	Caffeine µg/L	DEET µg/L	Triclosan µg/L	BTH µg/L
6/22/2016	0.00201	0.22467	0.05643	0.37087
7/27/2016	na	na	na	na
8/22/2016	na	na	na	na
9/19/2016	0.00664	1.83993	0.42191	0.01651

Table 4. Concentration of 4 human marker compounds in groundwater samples collected from a permanent piezometer in June and September off the Gourley site. July and August samples were not analyzed.

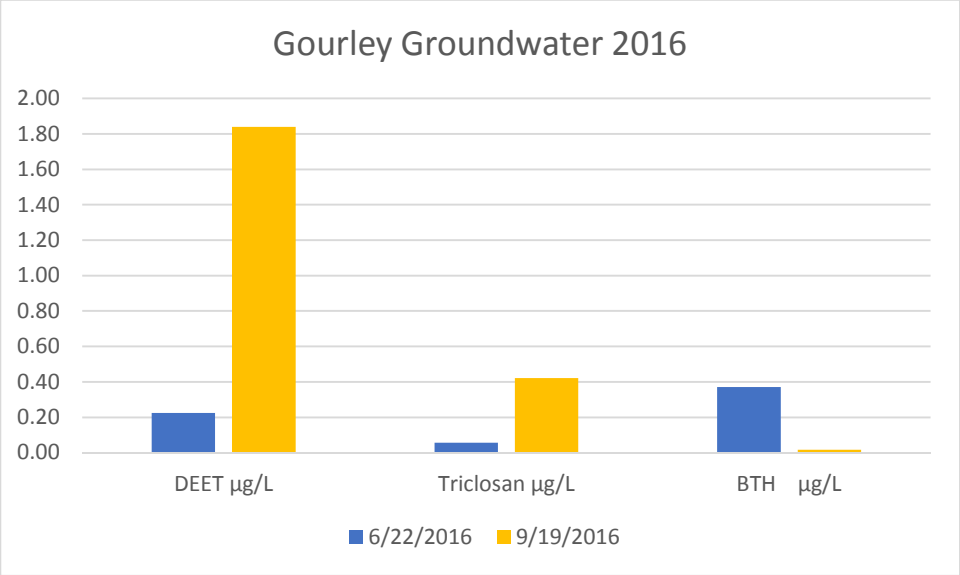

Figure 4. Three human marker concentrations in groundwater samples collected off the Gourley site in June and September 2016.

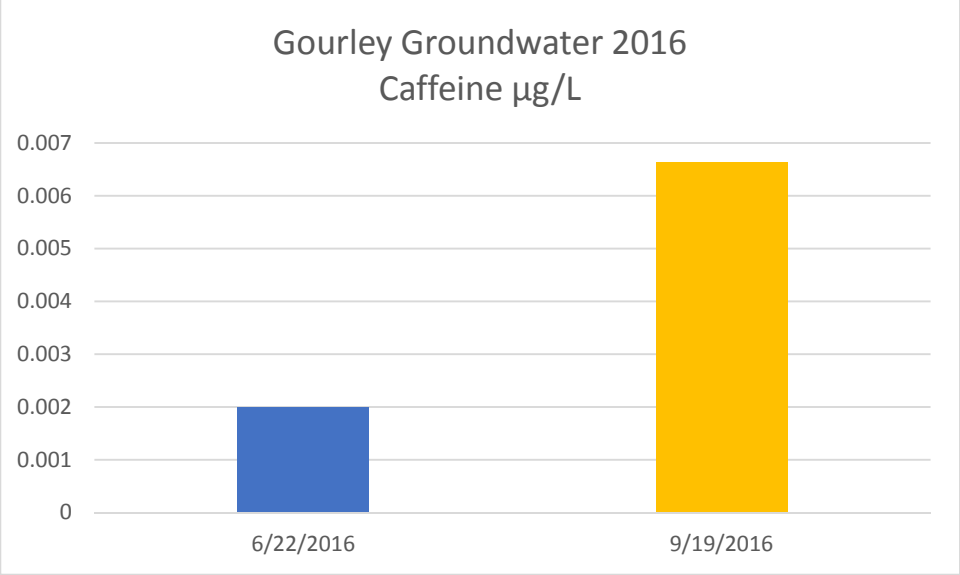

Figure 5. Caffeine concentration in groundwater samples collected off the Gourley site in June and September 2016.

All groundwater samples analyzed from the Gourley site contained human marker compounds (Figures 4 and 5). At this site, caffeine, DEET and triclosan concentrations in groundwater samples were higher at the end of the summer, while BTH concentration was higher at the beginning of the summer.

The Penoza residence is located north of Deepwater Point on the southwest shore of Torch Lake. Human marker concentrations for groundwater samples collected from the Penoza site are presented in Table 5.

A temporary piezometer was used to collect groundwater samples. At each sampling event, the piezometer was driven into the lake floor for sampling and removed after samples were collected. An effort was made to return to approximately the same spot for each sampling event.

Date	Caffeine µg/L	DEET µg/L	Triclosan µg/L	BTH µg/L
6/24/2016	0.00597	3.72765	0.07137	1.93823
7/26/2016	0.13298	11.13950	0.11534	0.04995
8/24/2016	BDL	13.08700	BDL	0.04044
9/19/2016	BDL	0.14559	BDL	0.01462

Table 5. Concentration of 4 human marker compounds in groundwater samples collected each month during the summer off the Penoza site on the southwest shore of Torch Lake.

Caffeine and triclosan concentrations were below detectable levels in the August and September groundwater samples. For graphing purposes, below detectable level, BDL was treated as 0.

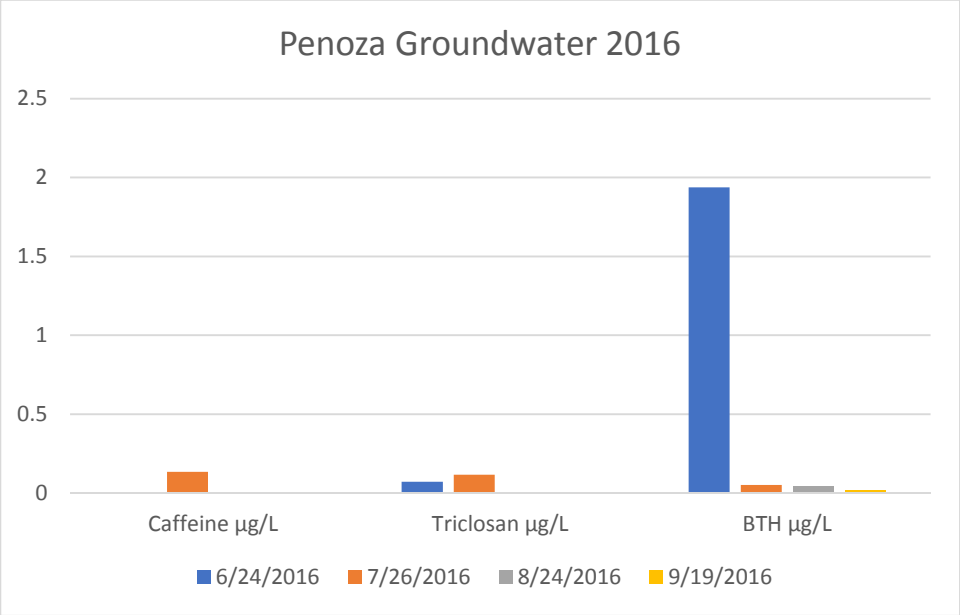

Figure 6. Concentration of 3 human marker compounds in groundwater samples collected with a temporary piezometer off the Penoza residence during the summer of 2016.

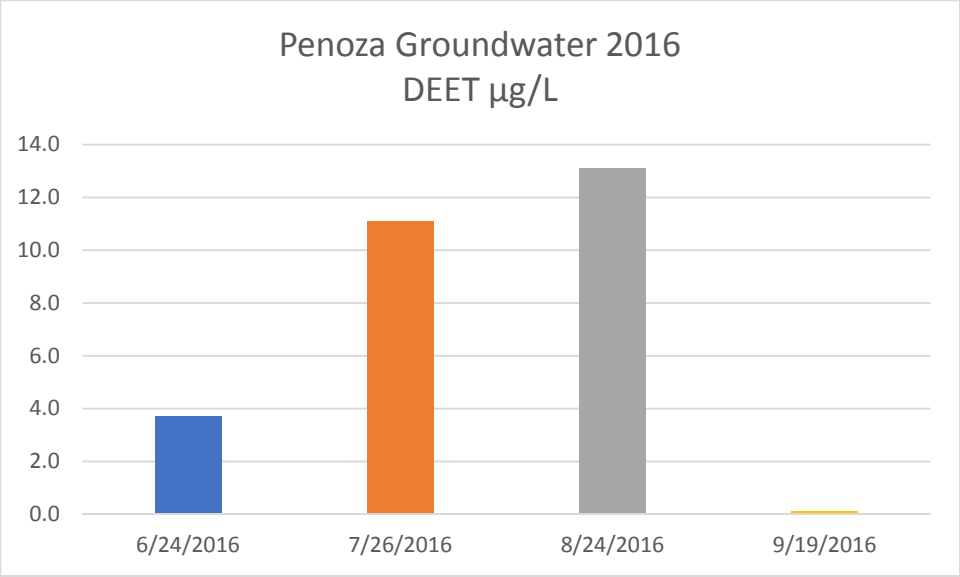

Figure 7. DEET concentration in groundwater samples collected off the Penoza residence during the summer of 2016.

Two of the 4 groundwater samples collected off the Penoza site (June and July) contained 4 human marker compounds throughout the summer months (Figures 6 and 7). At this site, caffeine and triclosan concentrations in groundwater samples were highest during the summer month of July. In the groundwater samples, BTH concentration peaked in June and DEET concentration peaked in August.

Conclusion

Sixty-nine percent (9 of 13) of the groundwater samples contained all 4 human markers. All of the groundwater samples that were analyzed for all 4 human marker compounds (13 samples) contained at least 2 of the 4 markers. Based on this study with limited sample numbers and replications, groundwater does carry compounds from septic drainfield effluents. Groundwater enriched with septic compounds can then be dispersed into the floor of Torch Lake from groundwater seeps.

Caffeine concentrations in groundwater samples peaked in July at the Petty, Hayo-went-Ha and Penoza sites. DEET concentration was highest in July in the groundwater samples from Petty and Hayo-went-Ha sites while the Penoza groundwater samples contained the highest concentration of DEET in August. Triclosan concentration was highest in July in the groundwater samples collected from Hayo-went-Ha and Penoza sites, while the Petty groundwater samples contained the highest concentration of triclosan in September. BTH concentration was consistently highest at all 4 sites in groundwater collected in June.

Variations in concentration peaks of these 4 human marker compounds in groundwater samples may be due to variability of human activities within the vicinity of the sites. We speculate that the high DEET concentration in groundwater collected in July at the Petty site may be due to spraying to control mosquitoes in the area or could be the result of analytical error.

BTH concentrations were highest in the June groundwater samples from Petty, Hayo-went-Ha, and Penoza sites. All four of the studied sites are used seasonally and vacant during the winter. The June BTH spike, soon after their first use of the plumbing, including the hot water heater, could be attributed to the plumbing being dormant for the past 6 months.

Groundwater samples from the Gourley site were not analyzed during the months of July and August making it difficult to compare temporal variations of the human marker compounds to the other sites. Data from the Gourley site, though fewer than from the other sites, show the same evidence of human markers.

Acknowledgments

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