FIELD STUDY OF WATER QUALITY EFFECTS OF TIRE SHREDS PLACED BELOW THE WATER TABLE

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ABSTRACT

A field trial was constructed to evaluate the water quality effects of tire shreds placed below the water table. The study consisted of three sites, each with 1.4 metric tons of tire shreds buried in a trench below the water table. The tire shreds were made from a mixture of steel and glass belted tires and had a maximum size of about 75 mm. The soil types at the sites were marine clay, glacial till, and peat. At each site, one water sampling well was located upgradient to obtain the background water quality, one well was located in the tire shred filled trench, and two to four wells were located 0.6 m to 3 m downgradient of the trench. Samples were taken over a four-year period and analyzed for a range of metals, volatile organics, and semivolatile organics. The results showed that tire shreds had a negligible effect on the concentration of metals with primary (health based) drinking water standards. For metals with secondary (aesthetic based) drinking water standards, samples from the tire shred filled trench had elevated levels of iron (Fe), manganese (Mn), and zinc (Zn). However, the concentrations of these metals decreased to near background levels for samples taken downgradient of the tire shred filled trench. Trace concentrations of a few organic compounds were found in the tire shred filled trenches, but concentrations were below method detection limits for virtually all the samples taken from the downgradient wells. Tire shreds placed below the water table appear to have a negligible off-site effect on water quality.

INTRODUCTION

Tire shreds are waste tires that have been cut into pieces that are generally 50 to 300 mm in size. They offer the following advantages when used as a fill material: lightweight, low lateral pressure, low thermal conductivity, and free draining[1]. Because of these advantages they have been used on more than 100 road construction projects across the United States. While the potential effect on groundwater quality is thought to be small when used for highway applications, there have been few extended studies of the effects for field conditions. Results from a 5-year field study of the water quality effects of tire shreds placed above the water table showed that tire shreds had a negligible impact on water quality for the near neutral pH conditions[2]. This paper presents the results of a companion study where the tire shreds were placed below the water table and monitored from1993 through 1997. The study included toxicity characteristic leaching procedure (TCLP) tests, a laboratory reactor study, and field installations[3,4]. However, this paper focuses on the field installations.

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FIELD SITES

The field portion of the study consisted of three sites where 1.4 metric tons of tire shreds were buried below the groundwater table in the following three soil types: peat (P), marine clay (C), and glacial till (T). The sites were located near Orono, Maine. The tire shreds had a 75-mm maximum size and were made from a mixture of steel and glass belted tires. Steel belts were exposed at the cut edges of the shreds. At each site, the tire shreds were placed in a 0.7 m to 1.8 m wide trench with its long axis oriented perpendicular to the approximate direction of groundwater flow. At each site, one monitoring well was installed upgradient of the tire shred filled trench to obtain background water quality; one well was installed directly in the tire shred filled trench; one to three wells were installed 0.6 m down gradient of the trench; and one well was installed about 3 m down gradient of the trench. Wells P1, C1, and T1 are located up gradient of the trench, while wells P2, C2, and T2,3 are located in the trench. Wells P3, P4, P5, C3, and T4 are located 0.6 m down gradient of the tire shred filled trench. Wells P6, C4, and T5 are located about 3 m down gradient. Samples were taken for a range of metals, volatile organics, and semivolatile organics.

METHODS

The following sample types were taken from each well: leachate filtered through a 0.3-micron filter and preserved with nitric acid (1.5 ml/L) [5]; unfiltered leachate preserved with nitric acid (1.5 ml/L) for determination of readily extractable total metals; and unfiltered leachate with no acid for water quality index tests such as pH. The unfiltered samples generally contained some fine grained particles. Since wells for drinking water are designed to prevent any significant amount of particulate matter from entering the well, it would not be representative to compare the results from unfiltered samples to drinking water standards. Thus, results from unfiltered samples provide supplementary information only and were not compared to drinking water standards.

Samples for the following metals were prepared in accordance with EPA Method 200.7 (Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis)[6]: aluminum, barium, calcium, chromium, copper, iron, magnesium, manganese, silver, sodium, and zinc. Except for silver, measurements were made using a Thermo Jarrell Ash Model 975 Plasma Atomcomp Inductively Coupled Plasma Emission Spectrometer. Silver was measured using a Thermo Jarrell Ash Atomic Absorption Sepctrometer Model Scan-1. Sample perparation for aresenic, cadmium, and lead followed EPA Method 200.9 (Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry)[6]. The tests were carried out using the atomic absorption furnace technique in accordance with EPA Method 7060 Arsenic; EPA Method 7131 Cadmium; and EPA Method 7421 Lead[7].

Samples were taken for volatile organic compounds (VOC's) and semivolatile organic compounds (SVOC's). The containers used for the VOC samples were clear 40 mL borosilicate glass vials with polypropylene closures and Teflon faced silicone septa. The samples were preserved by adding 4 drops of ultrapure hydrochloric (HCl) to each vial before collecting the samples. Leachate from the bailer was placed directly in the vial with no sample preparation. The VOC samples were tested in accordance with EPA

Method 8260 (Determination of Volatile Organics by Purge-and-Trap Capillary Column GC/MS). On most sample dates, 82 VOC's were targeted for analysis. SVOC samples were collected in 1 L amber borosilicate glass bottles with polypropylene closures with Teflon liners. Leachate from the bailer was placed directly in the bottles with no sample preparation. The SVOC samples were tested in accordance with EPA Method 8270 (Determination of Semivolatile Organics by Capillary Column GC/MS). On most sample dates, 69 base neutral extractable, acid extractable, and polyaromatic hydrocarbon SVOC's were targeted for analysis. The compounds for volatile and semivolatile organic analyses were chosen based on the chemical composition of tires and likely breakdown products. Two different laboratories were used for organic analyses.

METALS

Metals with Primary Drinking Water Standards

The following metals with a primary drinking water standard were included in the study: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), and lead (Pb). The concentration of arsenic (As), cadmium (Cd), and lead (Pb) were below the test method detection limit in all samples (15, 5, and 15 µg/L, respectively). The concentration of dissolved copper (Cu) was generally below the test method detection limit of 3 µg/L, however, background levels in a few samples were as high as 11 µg/L compared to levels up to 4 µg/L in the tire shred filled trenches. Thus, tire shreds do not appear to increase the levels of dissolved copper (Cu).

The concentration of dissolved barium (Ba) in the tire shred filled trench ranged from 7 to 57 µg/L compared to background levels of 6 to 33 µg/L. In the wells located 0.6 m downgradient of the tire shred filled trench the concentration of barium (Ba) had returned to background levels (5 to 39 µg/L). Thus, the tire shreds submerged in groundwater slightly increased the level of barium (Ba), but Ba did not show a tendency to migrate downgradient. More importantly, the level of dissolved Ba was less than its primary drinking water standard of 2000 µg/L, even in the tire shred filled trenches.

Metals with Secondary Drinking Water Standard

The following metals with secondary drinking water standards were included in the study: silver (Ag), aluminum (Al), iron (Fe), manganese (Mn), and zinc (Zn). The concentration of dissolved silver (Ag), aluminum (Al), and sodium (Na) in the tire shred filled trenches were generally similar to or less than background levels[4]. However, water in direct contract with submerged tire shreds had elevated levels of dissolved iron (Fe), manganese (Mn), and zinc (Zn) (Table 1). Dissolved iron (Fe) concentrations in the tire shred filled trenches ranged from nondetect to 86,900 µg/L compared to background concentrations of 22 to 3160 µg/L. However, in wells located 0.6 m downgradient of the tire shred filled trench the iron (Fe) concentrations deceased to nondetect to 3660 µg/L, which is comparable to background levels. The concentration of manganese (Mn) in the tire shred filled trench was 376 to 3340 µg/L compared to background levels of 27 to 666 µg/L. There were also increased concentrations of manganese (Mn) in the downgradient wells, however, the concentration appeared to decrease with time and was similar to

Table 1. Concentration of dissolved iron, manganese, and zinc.

		Concentration (µg/l)													
Compound	Date	Peat Site						Clay Site				Till Site			
		P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,T3	T4	T5
		up grad	in shreds	down gradient				up grad	in shreds	down gradient		up grad	in shreds	down gradient	
Fe	6/94	514	22500	279	664	214	155	18.4	17300	21.6	<10	22	4160	2710	33
Fe	9/94	1620	66800	974	1640	1830	1180	53	56300	35	33	*	6530	*	*
Fe	11/94	*	58600	1280	1790	1700	2330	476	56400	300	318	277	71700	352	618
Fe	4/95	3160	86900	2460	2900	2190	2450	<100	#	<100	#	134	47500	<100	<100
Fe	11/96	2950	2080	*	2640	3270	3490	*	ND	*	ND	*	ND	*	28
Fe	6/97	783	49600	*	3660	3320	*	*	ND	2710	ND	*	21800	*	172
Mn	6/94	574	732	726	690	814	1070	120	724	322	157	49	3340	95	288
Mn	9/94	666	1340	954	786	916	845	122	1850	890	653	*	2340	*	*
Mn	11/94	*	1150	900	742	850	584	82	1400	764	44	41	2450	39	662
Mn	4/95	583	1200	1090	812	493	658	49	#	532	#	27	2500	27	773
Mn	11/96	386	514	*	518	293	484	*	502	*	29	*	973	*	40
Mn	6/97	390	619	*	228	391	*	*	376	393	13	*	780	*	56
Zn	6/94	2.8	44.4	5.1	3.3	5.4	3.8	ND	10	2.1	ND	ND	7.6	5.6	2.4
Zn	9/94	3	25	5	ND	2	2	4	123	ND	ND	*	76	*	*
Zn	11/94	*	15	8	5	2	2	7	20	4	ND	4	10	<3	23
Zn	4/95	9	15	8	ND	8	7	4	#	ND	#	4	5	5	ND
Zn	11/96	ND	65	*	8	9	ND	*	ND	*	ND	*	ND	*	ND
Zn	6/97	ND	14	*	7	6	*	*	ND	ND	ND	*	ND	*	ND

Notes: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit (DL); see Tables 2 and 3 for detection limits.

background levels in the most recent round of sampling. Zinc (Zn) concentrations were also increased somewhat by tire shreds. The dissolved zinc (Zn) concentration in the tire shred filled trench ranged from below the detection limit to 123 µg/L compared to background levels that varied from below the detection limit to 9 µg/L. However, the zinc (Zn) in the tire shred filled trench decreased with time over the course of the study. The zinc (Zn) in downgradient wells was comparable to background levels.

Concentration of Metals for Unfiltered Samples

Unfiltered concentrations of silver (Ag), aluminum (Al), arsenic (As), barium (Ba), calcium (Ca), cadmium (Cd), copper (Cu), magnesium (Mg), sodium (Na), and lead (Pb) in the tire shred filled trenches were about the same or lower than background levels[4]. However, unfiltered levels of iron (Fe) in the tire shred filled trenches was significantly higher than background levels (Table 2 – note: due to the high Fe concentrations in Table 2, the units are expressed in mg/L whereas µg/L were used for all other concentrations).

This is most likely due to iron oxide precipitate that was visible in water that was in direct contact with the tire shreds. However, there is a general trend of decreasing concentration with time. Moreover, the Fe in wells located 3 m down gradient of the tire shred filled trench was similar to background levels. Unfiltered levels of manganese (Mn), and zinc (Zn) were also elevated in the tire shred filled trench (Table 3) but the levels tended to decrease with time and with distance downgradient from the trench. The unfiltered concentrations of chromium (Cr) in the tire shred filled trench at the peat and till sites tended to be higher than the background levels (Table 4). On some sampling dates, the total chromium concentration was higher in the downgradient wells than either the upgradient well or tire shred filled trench.

Table 2. Unfiltered iron concentration (mg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
Fe	6/94	0.01	1.8	111	3.2	2.7	1.1	0.1	25	69	33	40	14	155	113	19
Fe	9/94	0.1	0.4	292	4.3	5.9	4.5	3.7	57	209	198	15	*	117	*	*
Fe	11/94	0.1	*	212	8.2	9.2	4.6	9.7	76	195	111	75	64	209	120	70
Fe	4/95	0.1	12	216	12	11	5.7	8.8	78	109	77	78	70	213	817	47
Fe	11/96	0.015	0.7	#	*	0.8	0.9	1.0	*	ND	ND	ND	*	ND	*	ND
Fe	6/97	0.015	4.8	76	*	5.7	8.0	6.9	*	3.4	0.6	3.9	*	39	*	5.8
Fe	6/97	0.015	0.2	52	*	1.9	2.3	4.1	*	0.07	4.6	0.7	*	#	*	#

Table 3. Unfiltered manganese (Mn) and zinc (Zn) concentrations (µg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shr.	down gradient	
Mn	6/94	5	1300	1490	1880	1710	1730	1860	503	1570	984	468	365	7000	2620	890
Mn	9/94	5	1440	2830	2220	1930	1850	1830	1610	3880	3590	2530	*	5450	*	*
Mn	11/94	5	*	2300	2410	1770	1720	1490	1900	2830	2690	1360	1010	4990	2710	2260
Mn	4/95	5	1370	2440	2680	2100	1080	1080	1340	1990	1650	1060	1330	5340	13500	2160
Mn	11/96	5	405	#	*	491	473	282	*	ND	499	ND	*	971	*	ND
Mn	6/97	2	381	686	*	250	573	600	*	377	372	37	*	741	*	323
Mn	6/97	2	329	622	*	214	401	504	*	316	408	7	*	#	*	#
Zn	6/94	2	14	2390	25.2	143	66.5	16.3	100	747	198	72.3	42.7	338	307	45.8
Zn	9/94	2	40	561	39	19	18	45	167	675	531	341	*	569	*	*
Zn	11/94	3	*	261	17	8	ND	31	152	95	298	132	103	54	276	99
Zn	4/95	2	28	107	14	ND	ND	10	183	107	171	174	134	205	1540	83
Zn	11/96	7	ND	#	*	ND	ND	10	*	ND	ND	ND	*	15	*	ND
Zn	6/97	5.7	ND	96	*	10	10	10	*	7	ND	11	*	24	*	27
Zn	6/97	5.7	ND	13	*	ND	ND	ND	*	ND	ND	ND	*	#	*	#

Notes for Tables 2 and 3: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit; DL = detection limit

Table 4. Unfiltered chromium (Cr) concentration (µg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
Cr	6/94	2	3	17	4	2	ND	ND	49	25	60	66	33	62	249	38
Cr	9/94	2	5	22	2	4	2	3	101	26	317	231	*	85	*	*
Cr	11/94	2	*	18	ND	8	4	2	114	16	205	105	93	33	248	92
Cr	4/95	2	10	21	8	5	3	2	128	39	124	118	99	114	1240	68
Cr	11/96	6	ND	#	*	ND	ND	ND	*	ND	ND	ND	*	ND	*	ND
Cr	6/97	6	ND	ND	*	ND	ND	ND	*	8	ND	10	*	7	*	13
Cr	6/97	6	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	#	*	#

Notes: * = no sample on that date; # = compound not included in analysis on that date;
ND = below detection limit; DL = detection limit

VOLATILE ORGANIC COMPOUNDS

Results for volatile organic compounds with the highest concentrations are summarized in Table 5. Cis-1,2-dichloroethene was found in samples from the tire shred trenches on most sampling dates. Except for one sample, the concentration was below its drinking water standard of 70 µg/L. The exception had a concentration of 85.5 µg/L. The highest concentration found in the wells located down gradient of the trenches was 9.8 µg/L. The results show that tire shreds submerged in groundwater release low concentrations of cis-1,2-dichloroethene, however, the concentration even a short distance (0.6 m) down gradient of tire shreds was well below the compound's drinking water standard.

Benzene appears to be released from tire shreds at trace levels. The measured concentrations were less than the drinking water standard (5 µg/L) except for two samples tested by the University of Connecticut. Duplicate samples tested by Northeast Laboratory found concentrations less than 5 µg/L. The concentration of benzene in wells 0.6 m down gradient of the trench were generally below detection limits except for two samples that had concentrations of 1 and <5 µg/L.

Tire shreds release low levels of 1,1-dichoroethane, 4-methyl-2-prentanone (MIBK), and acetone. The concentration 1,1-dichoroethane in samples taken from the tire shred trenches ranged from nondetect to 19 µg/L. However, the concentrations in the wells down gradient from the trenches were below the detection limit in the most recent round of sampling. Methyl-2-pentanone (MIBK) was found in samples from the tire shred trenches at concentrations ranging from nondetect to 140 µg/L, however the highest concentration in a well located 0.6 m down gradient from the trench was 31 µg/L. The concentration of acetone in the tire shred trenches ranged from nondetect to 54 µg/L for acetone, however, this compound is naturally produced by human metabolism and is not a major health concern at low concentrations. Tire shreds appear to release trace levels of 1,1,1-trichloroethane, 1,1-dichloroethene, xylenes, toluene, trichloroethene, 2-butanone (MEK), and chloroethane. The concentrations are generally less than 10 µg/L. For compounds that have a drinking water standard, the levels were well below the standard[4].

Table 5. Concentration of selected volatile organic compounds.

Concentration are in µg/L				Peat Site						Clay Site				Till Site			
Compound	Lab	Date	DL	P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
				up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
1,1-dichloro-	C	08/94	0.5	ND	2.5	ND	ND	ND	ND	ND	1.9	6.9	ND	*	14.3	*	*
ethane	C	11/94	0.5	*	ND	ND	ND	ND	ND	ND	7	5	ND	ND	19	ND	ND
	N	11/95	5	*	5.9	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	6.4	ND	ND	ND	*	ND	2.5	2.5	0.9	ND	12.7	3.9	ND
	N	09/96	5	*	5.8	*	*	*	*	*	<5	*	*	*	ND	*	*
	C	09/96	0.5	*	5.4	*	*	*	*	*	ND	*	*	*	0.7	*	*
	N	11/96	5	ND	<5	*	ND	ND	ND	*	<5	<5	ND	ND	12	ND	ND
	N	06/97	5	ND	<5	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
4-methyl-2-	N	11/95	5	*	140	*	*	*	*	*	*	*	*	*	*	*	*
pentanone	N	09/96	5	*	40	*	*	*	*	*	21	*	*	*	ND	*	*
	N	11/96	5	ND	24	*	ND	ND	ND	*	ND	31	ND	ND	100	ND	ND
	N	06/97	5	ND	23	ND	ND	ND	*	*	ND	15	ND	ND	*	ND	ND
acetone	N	11/95	10	*	54	*	*	*	*	*	*	*	*	*	*	*	*
	N	09/96	10	*	21	*	*	*	*	*	10	*	*	*	ND	*	*
	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	40	ND	10
	N	06/97	10	ND	13	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
benzene	C	08/94	0.5	ND	0.7	ND	ND	ND	ND	ND	1.4	ND	ND	*	1.8	*	*
	C	11/94	0.5	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	N	11/95	5	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	1.8	ND	ND	ND	*	ND	2	1	ND	ND	1.5	ND	ND
	N	09/96	5	*	<5	*	*	*	*	*	<5	*	*	*	ND	*	*
	C	09/96	0.5	*	21	*	*	*	*	*	9.5	*	*	*	ND	*	*
	N	11/96	5	ND	<5	*	ND	ND	ND	*	ND	<5	ND	ND	ND	ND	ND
	N	06/97	5	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
chloroethane	C	08/94	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	1.1	*	*
	C	11/94	1	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	N	11/95	10	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	1	ND	ND	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND
	N	09/96	10	*	<10	*	*	*	*	*	ND	*	*	*	ND	*	*
	C	09/96	1	*	6.7	*	*	*	*	*	ND	*	*	*	ND	*	*
	N	11/96	10	ND	<5	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
	N	06/97	10	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
cis-1,2-di-	C	08/94	0.5	ND	16.1	ND	ND	ND	ND	ND	9.2	ND	ND	*	33.4	*	*
chloroethene	C	11/94	0.5	*	6	ND	ND	ND	ND	ND	34.5	8.5	ND	ND	85.5	ND	ND
	N	11/95	5	*	25	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	36.9		ND	4.2		ND	9.4	7	0.8	ND	44.7	9.8	ND
	N	09/96	5	*	29	*	*	*	*	*	6.4	*	*	*	ND	*	*
	C	09/96	0.5	*	32.2	*	*	*	*	*	7.9	*	*	*	1	*	*
	N	11/96	5	ND	26	*	ND	ND	ND	*	6	7.9	ND	ND	43	ND	ND
	N	06/97	5	ND	27	<5	ND	ND	*	*	<5	6	ND	ND	*	<5	ND

Notes: * = no sample on that date; ND = below detection limit; DL = method detection limit; C = sample tested by University of Connecticut; N = sample tested by Northeast Laboratory

SEMIVOLATILE ORGANIC COMPOUNDS

For the first few years after placement, tire shreds submerged in groundwater release low levels of aniline and phenol (Table 6). For samples taken through October 1996, aniline was present above the detection limit in most of the samples taken from the tire shred trenches. When detected, the concentrations ranged from 20 to 200 µg/L. However, no detectable levels of aniline were found in the two most recent rounds of samples. Phenol was found in the samples taken from the tire shred trenches at all three sites in November, 1994, and April, 1995. The concentrations ranged from 16 to 55 µg/L. The levels were nondetect in the first round of samples in August, 1994, and in all samples taken on or after November, 1995. More importantly, no detectable levels of either compound were found in the down gradient wells.

m&p cresol was present above the detection limit in slightly more than half of the samples taken from the tire shred trenches. When detected, concentrations ranged from 13 to 86 µg/L. Except for two samples at the clay site, neither compound was found in the down gradient wells. Thus, m&p cresol is released at low concentrations, however, it has a negligible tendency to migrate down gradient.

It is likely that tire shreds release trace levels of benzoic acid and N-nitrosodiphenyl-amine. Benzoic acid was found in about one-quarter of the samples taken from the tire shred trenches at concentrations ranging from <10 to 100 µg/L. N-nitrosodiphenylamine was found in about one-third of the samples taken from the tire shred trenches at concentrations ranging from <10 to 11.2 µg/L. Except for one sample each, these compounds were not found in the down gradient wells.

The following compounds were found above the detection limit in a few samples: benzothiazole, 2(3H)-benzothiazolone, 3-methylbenzenamine, and di-n-butyl-phthate. It is possible that tire shreds sporadically release low levels of these compounds. Several compounds were reported at levels above the detection limit in one well on a single date. This includes: cyclohexanol, 2,6-bis-(1,1-dimethylethyl)-2,5-cyclohexadiene-1,4-dione, 1H-isoindole-1,3(2H)-dione, 4-(2-benzothiazolythio)-morpholine, N-(1,1-dimethlyethyl)-formamide, butanoic acid, and isothiocyanato cyxlohexane. It is possible that tire shreds sporadically release low levels of these compounds. However, it is more likely that these are spurious data points and that tire shreds do not release detectable levels of these compounds.

Nine semi-volatile compounds were tentatively identified on a single date in the tests performed by the University of Connecticut. The compounds are: cyclohexanol, 2,6-bis-(1,1-dimethylethyl)-2, 1H-isoindole-1,3(2H)-dione, 4-(2-benzothiazolythio)-morpholine, N-(1,1-dimethlyethyl)-formamide, butanoic acid, diethytoluamide (DEET), 3-methylbenzenamine, and isothiocyanato cyxlohexane. In addition, benzothiazole was tentatively identified on three sampling dates and 2(3H)-benzothiazolone was tentatively identified on two sampling dates. There were also unidentified compounds on two dates. The estimated concentrations of these compounds are given in Table 6. It is possible that tire shreds release low concentrations of these compounds.

Table 6. Concentration of selected semivolatile organic compounds.

Concentration in µg/L				Peat Site						Clay Site				Till Site			
Compound	Lab	date	DL	P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
				up gr.	in shred	down gradient				up gr.	in shred	down gradient		up gr.	in shred	down gradient	
aniline	C	8/94	10	ND	58	ND	ND	ND	ND	ND	*	ND	*	*	31	*	*
aniline	C	11/94	10	*	20	ND	ND	ND	ND	ND	91	ND	ND	*	64	ND	ND
aniline	C	4/95	--	#	#	#	#	#	#	#	#	#	#	#	(40)	#	*
aniline	N	11/95	10	*	81	*	*	*	*	*	*	*	*	*	*	*	*
aniline	C	11/95	--	*	(30)	*	*	#	*	*	*	*	*	*	*	*	*
aniline	C	7/96	--	#	#	*	#	#	#	#	#	#	#	#	(100)	#	#
aniline	N	10/96	10	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
aniline	C	10/96	--	*	(200)	*	*	*	*	*	(65)	*	*	*	#	*	*
aniline	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	ND	ND	ND
aniline	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
phenol	C	8/94	20	ND	ND	ND	ND	ND	ND	ND	*	ND	*	*	ND	*	*
phenol	C	11/94	20	*	55	ND	ND	ND	ND	ND	16	ND	ND	*	26	ND	ND
phenol	C	4/95	20	ND	27	ND	ND	ND	ND	ND	22	ND	ND	ND	51	ND	*
phenol	N	11/95	10	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
phenol	C	11/95	20	*	ND	*	*	ND	*	*	*	*	*	*	*	*	*
phenol	C	7/96	20	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenol	N	10/96	10	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
phenol	C	10/96	20	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
phenol	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	ND	ND	ND
phenol	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
m&p cresol	C	8/94	20	ND	ND	ND	ND	ND	ND	ND	*	ND	*	*	ND	*	*
m&p cresol	C	11/94	20	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND	ND
m&p cresol	C	4/95	20	ND	32	ND	ND	ND	ND	ND	42	ND	ND	ND	86	ND	*
m&p cresol	N	11/95	10	*	13	*	*	*	*	*	*	*	*	*	*	*	*
m&p cresol	C	11/95	20	*	20	*	*	ND	*	*	*	*	*	*	*	*	*
m&p cresol	C	7/96	20	ND	29	*	ND	ND	ND	ND	39	ND	ND	ND	82	ND	ND
m&p cresol	N	10/96	10	*	14	*	*	*	*	*	31	*	*	*	ND	*	*
m&p cresol	C	10/96	20	*	42	*	*	*	*	*	24	*	*	*	ND	*	*
m&p cresol	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	18	ND	*	57	ND	ND
m&p cresol	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	<10	ND	ND	32	ND	ND
benzothiazole	C	4/95	--	#	#	#	#	#	#	#	(50)	#	#	#	#	#	*
benzothiazole	C	11/95	--	*	(100)	*	*	#	*	*	*	*	*	*	*	*	*
benzothiazole	C	10/96	--	*	(300)	*	*	*	*	*	(300)	*	*	*	#	*	*
2(3H)-benzo-	C	4/95	--	#	(200)	#	#	#	#	#	(100)	(100)	#	#	(100)	#	*
-thiazolone	C	10/96	--	*	(300)	*	*	*	*	*	(300)	*	*	*	#	*	*
Unknown	C	4/95	--	#	(700)	#	#	#	#	#	(40)	(480)	(239)	#	(600)	(150)	#
Unknown	C	4/95	--	#	(200)	#	#	#	#	#	#	#	#	#	#	#	#

Notes: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit; ()= tentatively identified compound; DL = method detection limit; C = sample tested by University of Connecticut; N = sample tested by Northeast Laboratory

CONCLUSIONS

The results showed that tire shreds had a negligible effect on the concentration of metals with primary (health based) drinking water standards. For metals with secondary (aesthetic based) drinking water standards, samples from the tire shred filled trench had elevated levels of iron (Fe), manganese (Mn), and zinc (Zn). However, the concentrations of these metals decreased to near background levels for samples taken 0.6 to 3 m downgradient of the tire shred filled trench. Trace concentrations of a few organic compounds were found in the tire shred filled trenches, but concentrations were below method detection limits for virtually all the samples taken from the downgradient wells. Tire shreds placed below the water table appear to have a negligible off-site effect on water quality.

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