Report as of FY2009 for 2009NY121B: "The fate of non point sources of nitrate in lawn maintenance "

Publications

Project 2009NY121B has resulted in no reported publications as of FY2009.

Report Follows

Project Report May, 2010

The Fate of Non-Point Sources of Nitrate in Lawn Maintenance

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INTRODUCTION

Quantifying nitrate leaching from fertilizer practices of turfgrass lawns is essential to keep concentrations in groundwater below the U.S. Environmental Protection Agency drinking water standard of 10 mg/L especially in areas served by septic tanks (Baier and Rykbost, 1976; Porter, 1980; Flipse and Bonner, 1985; Flipse et al., 1984; Kimmel, 1984). Concentrations of $N\text{-}NO^3$ in soil water leachate are commonly less than 5 mg/L beneath fertilized turf (Petrovic, 1990), however, under certain conditions, concentrations can reach 40 mg/L (Frank et al., 2006; Guillard and Kopp, 2004). Recently established plots of mixed grass species, for example, might leach ten times more nitrate than did areas planted with homogenous grass (Erickson et al., 2001). On Long Island, NY the potential for nitrate leaching to the groundwater is particularly high due to the sandy soils and the large volume of infiltration from rain and irrigation sprinklers. Twenty-five percent of the land has been classified as turfgrass (Koppelman, 1978) **t**he Suffolk County Water Authority estimates that 73 billion liters annually (30%) of the annual water consumption in Suffolk County is used for irrigation. In addition, about half of the 112.2 cm of precipitation received each year infiltrates to the groundwater (Busciolano, 2004).

"More studies are needed to determine the fate and transport of $N\text{-}NO^3$ applied to turf in urban or suburban settings" (Guillard and Koop (2004) including multiyear investigation of slow-release, nitrogen fertilizers and for more leaching studies using different sources of nitrogen (Petrovic, 1993). Such long-term monitoring studies can define the interannual variability. Investigations elsewhere are, of course, useful but regional conditions and practices need to be examined to determine the impact to groundwater reserves (Petrovic, 1990).

PREVIOUS WORK

Porter (1978;1980), conducted a field survey to evaluate the impact of lawn fertilizer to groundwater in urban areas of Nassau and Suffolk County, NY. The sites received ammonium nitrate-nitrogen fertilizer, a fertilizer no longer commonly used because of environmental concerns and a preference for slow-release forms of nitrogen. Just below the root zone, concentrations as high as 32.5 mg/L were found. From such data, Porter (1978) calculated that fertilizers applied to recreational lawns are estimated to contribute between 29-35% of the nitrogen load to Long Island aquifers.

In 2001, studies were begun on Long Island to measure nitrate concentrations beneath urban lawns that are fertilized with either organic or chemical fertilizers (Schuchman 2001, Munster 2008). Samples were also taken below unfertilized turf and in a forest setting. Soil water nitrate concentrations were collected below the turfgrass root zone from ceramic suction lysimeters at depths of 60 cm, 80 cm, 100 cm and either 120 or 150 cm. Sites were chosen to represent a diverse range of conditions across Suffolk County. Site conditions and fertilizer treatments varied indicative of natural conditions because homeowners and landscapers will not always fertilize in the same way from year to year. By 2003, measurements were being made beneath eight turfgrass sites. Higher average $N\text{-}NO^3$ concentrations measured under the plots treated with chemical fertilizer (14 ± 3 mg/L) than the plots treated with organic fertilizer (6.2 ± 1.1) perhaps due to excess applications of chemical fertilizer (Munster, 2008).

METHODS

Observations were made at three of the original eight sites in 2007. These were Oakdale (an organically fertilized site at 40 44' 54.40"N; 73 08' 16.67"W and chemically fertilized site at 40^{o} 44' 53.92"N; 73^{o} 08' 10.35"W); Hauppauge (40^{o} 48' 27.74"N; 73^{o} 15' 06.38"W) and Huntington (40^{o} 52' 08.95"N; 73^{o} 25 '03.77"W). The instrumentation at Huntington was lost at the end of 2008, but measurements were continued monthly at the other two sites through 2009. The Huntington organically fertilized site was 280 m^2 directly adjacent to the chemically fertilized site which is 330 m^2. The Oakdale organically fertilized site was in a 510 m^2 lawn surrounded by a parking lot and roads. The Oakdale chemically fertilized site and an additional organically fertilized site were about 30 meters away. The chemically fertilized site is rectangular, 665 m^2, and directly adjacent to the organic site which is 225 m^2. The Hauppauge organically fertilized site was 215 m^2 and separated by a few large trees from the chemically fertilized site which covered 250 m^2.

Turfgrass at the study sites were typical of the region, such as, the Dura-Sod blend of Fescue and Bluegrass at one site as recommend by the manufacture for the Long Island area (Schuchman, 2001). Turfgrass may be intermixed with naturally occurring clovers, crabgrass, moss and other weeds. Soil type was classified according to the mapped units (Warner, 1975) and particle size was previously determined (Munster et al., 2006). The organic fertilizers were composed of natural sulfate of potash, phosphate rock, colloidal phosphate, oyster meal, kelpmeal, greensand, vegetable and animal protein meals, natural nitrate of soda, compost, and dried whey. Manure was not used.

Both sites were watered with an automatic sprinkler system twice per week providing infiltration between 3.8 and 5.1 cm per week (www.scwa.com, Oral communication Michael DeBlasi, SCWA, August 2004). The sites are mowed between April and November and the clippings are not removed. Soil water samples from lysimeters were taken monthly, filtered in the field, stored in acid-rinsed polypropylene bottles and, once in the laboratory, frozen (-10ºC) until analyzed. On average 250 mL were collected but sample volume ranged from 5 to 450 mL. Concentrations of $N\text{-}NO^2$, NH^4 and $N\text{-}NO^3$ were analyzed at the School of Marine and Atmospheric Sciences at Stony Brook University on a Lachat's QuickChem8500 Flow Injection Analysis System using

Lachat's Method 10-107-04-1-J. Five to ten milliliters of sample are needed for analysis. These analyses have an uncertainty of 5% determined by anonymous standards and duplicate analysis. Detection limits were 0.1 mg/L for all ions. Nitrite and ammonium were rarely detected in the soil water samples.

RESULTS

Table 1 Summary of soil water N-NO3 concentrations at 100 cm and for bulk precipitation.

Year	n	Avg.	StD	Max.
		Chemical		
Combined	176	9.7	12	76
2003	23	3.1	2.3	7.6
2004	23	9.9	6.7	26
2005	32	7.7	7.1	27
2006	47	12.3	14.4	76
2007	14	27.2	29.1	123.0
2008	18	23.0	19.0	81.2
2009	19	11.9	8.5	32.9
		Organic		
Combined	279	6.5	8.1	45.3
2003	53	4.8	6.0	33.3
2004	53	3.6	3.9	24.8
2005	47	6.3	6.8	31.5
2006	50	11.4	11.8	45.3
2007	23	8.0	12.5	66.1
2008	27	3.0	2.9	17.3
2009	26	5.7	9.0	57.3
		Precipitation		
2005-2009	26	5.7	9.0	13.1
		Unfertilized turf		
Combined	68	1.29	1.3	5.58
2003	9	2.44	1.58	4.74
2004	12	1.2	1.09	3.98
2005	22	0.83	0.63	2.41
2006	23	1.17	1.46	5.58
		Forest		

Combined	26	0.4	1.01	3.9
2005	10	0.11	0.08	0.26
2006	9	0.07	0.05	0.14

The data is tabulated in Table 1. Monthly nitrogen as nitrate concentrations in soil water collected at 100 cm varies throughout the study period, but both the concentrations and variability were similar to that seen at these sites between 2001 and 2006 (Figure 1a and 1b).

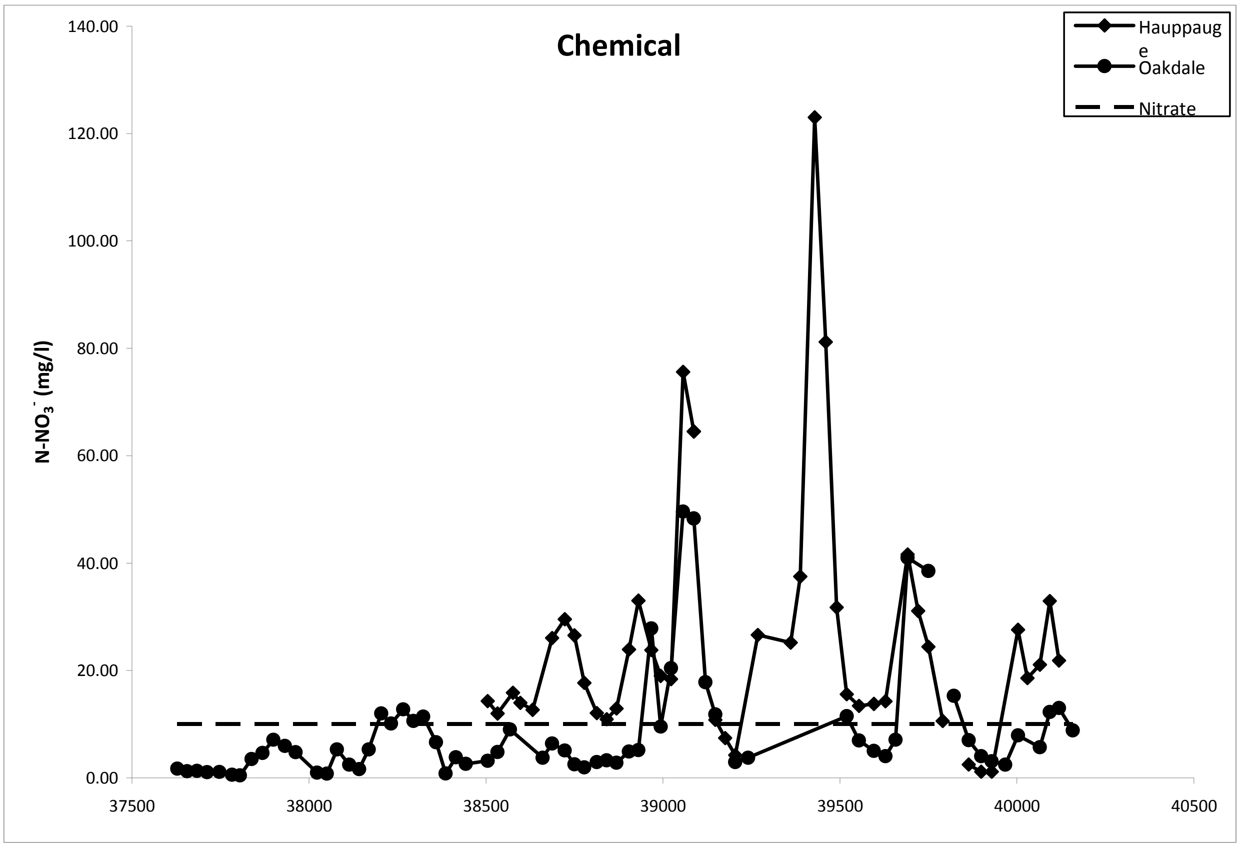

Figure 1a. Time series of nitrate concentrations in soil-water 100 cm below chemically fertilized turf.

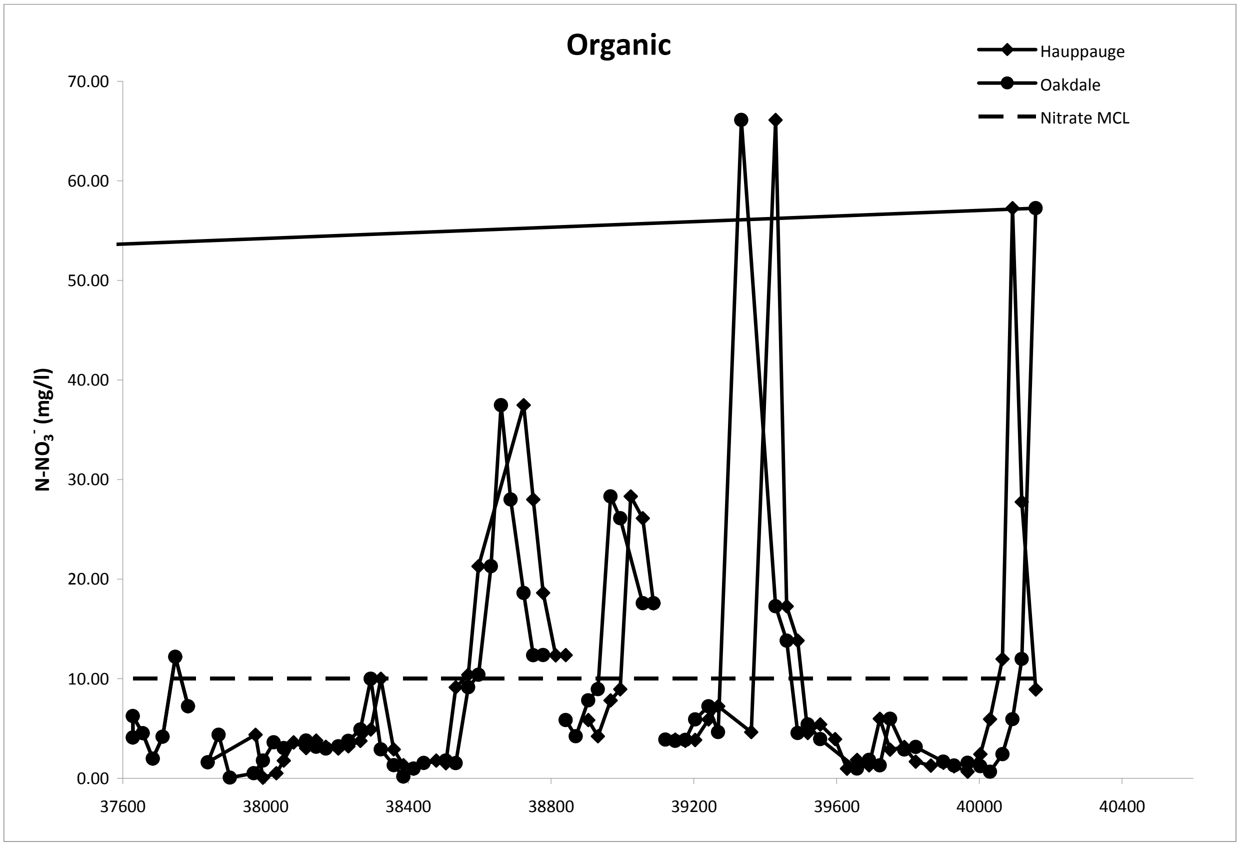

Figure 1b. Time series of nitrate concentrations in soil-water 100 cm below organically fertilized turf.

Highest concentrations were seen over the winter months (Figure 2) except in the winter of 2008-2009, when fertilization in the fall (October) was not done. The organically fertilized site at Oakdale consistently showed lower concentration than that at Hauppauge. The Oakdale site had been more recently disturbed and it may be the turf there was still in the process of maturation.

There is a difference in soil-water $N\text{-}NO^3$ concentrations at 100 cm, on average, between different fertilizer treatments however, there is also variability between sites that receive the same type of fertilizer. This variability could be due to variable moisture and temperature differences from year to year, although concentrations at a given site do not vary much between years or to difference in soil and hydrologic properties (Munster et. al., 2006).

The sites treated with chemical fertilizer leach, on average, more nitrate than the sites treated with organic fertilizer (Figure 3). This difference may be due to differences in site properties and not a function of fertilizer treatment, as average soil water $N\text{-}NO^3$ concentrations vary between sites, even between sites treated with the same type of fertilizer.

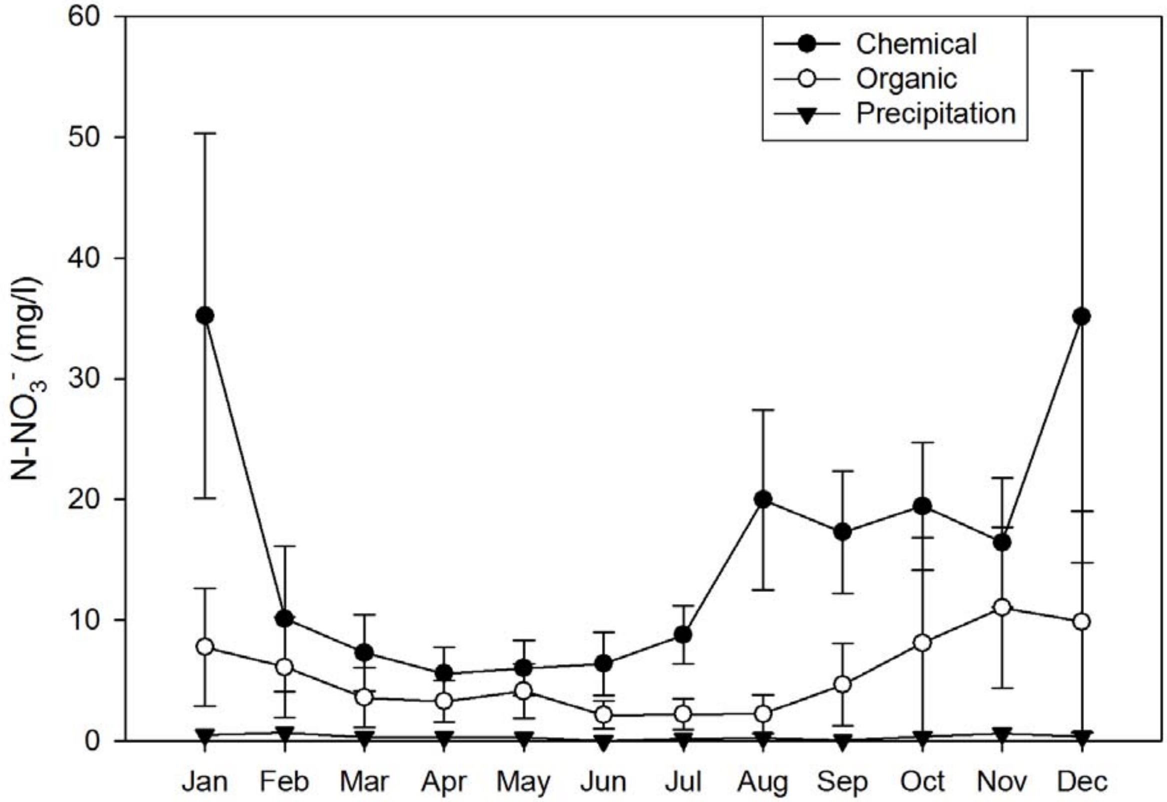

Figure 2. Average monthly N-NO^3 values of soil water collected at 100 cm from the combined years 2003-2009. Bulk precipitation collected from January 2005 to December 2009. Error bars are standard error of the mean. The regulated drinking water standard is 10 mg/L.

Higher soil water average N-NO^3 concentrations under the sites treated with chemical fertilizer than those treated with organic fertilizer could be due to higher rates of applied nitrogen at the sites treated with chemical fertilizer, although there is no direct relationship between yearly application rate and average concentrations. Even when soil and hydrologic properties are relatively constant sites fertilized with organic fertilizer can leach similar concentrations of nitrate as chemical sites even though inputs of nitrogen are less at the organic sites.

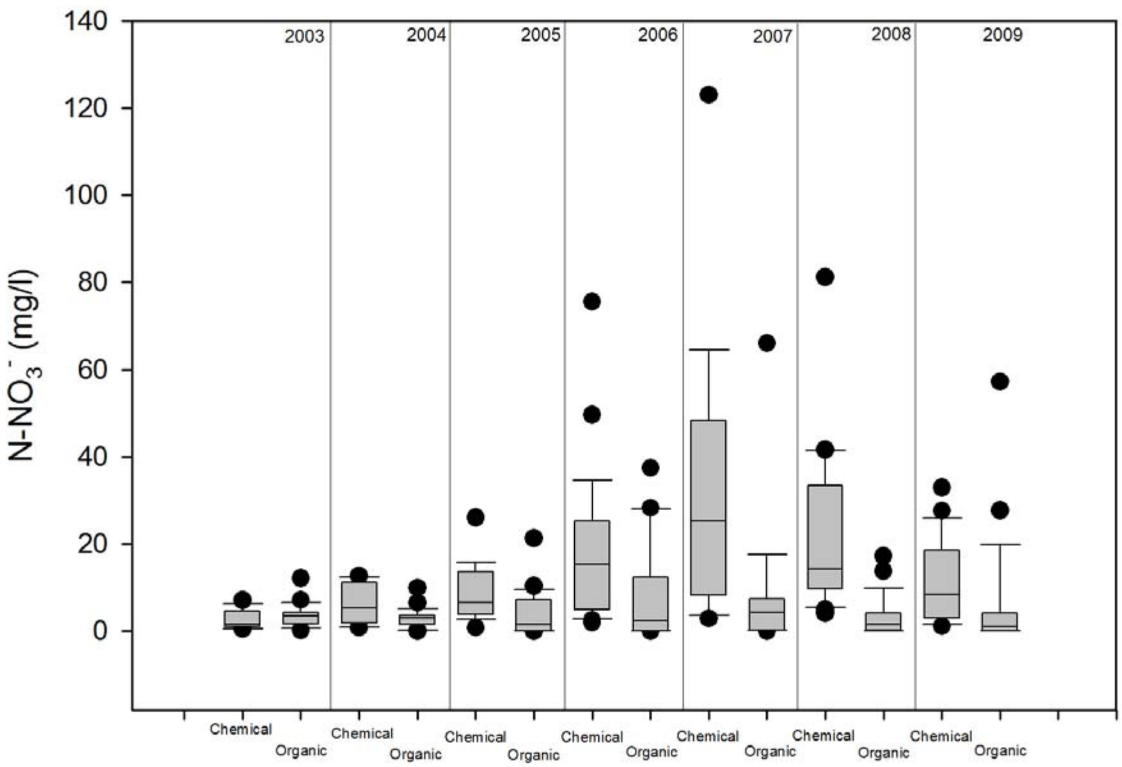

Figure 3. Box plot of soil-water N-NO^3 concentrations at 100 cm for each study plot for the years 2003-2009

CONCLUSIONS

On average, concentrations of soil water N-NO^3 collected at 100 cm beneath lawns treated with chemical fertilizer was higher than soil water collected beneath lawns treated with organic fertilizer or no fertilizer. Water collected beneath lawns treated with organic fertilizer were routinely found to be above the EPA drinking water standard of 10 mg/L even though these sites received less than a third the amount of nitrogen as the lawns treated with chemical fertilizer. However, the likelihood of concentrations of soil-water at one meter to exceed 10 ppm was lower for sites treated with organic fertilizer than it is for sites treated with chemical fertilizer, but the use of organic fertilizer alone does not guarantee lower nitrate concentrations or that the use of turfgrass fertilization alone may not raise groundwater concentrations above the drinking water standard for nitrate.

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