Watershed Protection Development Review

Impacts of Lawn Fertilizers on the Environment in Austin, Texas

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Lawn fertilizers containing pesticides, herbicides, dissolved salts and nutrients are a potential source of pollutants to Austin area waterways. The City of Austin is developing recommendations on the type and quantity of fertilizer to apply to minimize pollutant impacts that result from their use. Two studies on the environmental impacts of fertilizer use are discussed here. The first study is a controlled greenhouse experiment conducted at Texas A&M University. The second study, which is not yet complete, is a field experiment using several different formulations of fertilizer on residential turf grass in a neighborhood in northwest Austin. Conclusions from the greenhouse study and preliminary data from the field study indicate that organic fertilizers with low proportions of phosphorus are the least polluting fertilizer type for the Austin area.

This document was last amended on 26 April, 2005.

INTRODUCTION

Lawn fertilizers are a potential source of pollutants to Austin area waterways. The City of Austin is working to provide recommendations on the type and quantity of fertilizer to apply to minimize pollutant impacts and ensure ample nutrients for healthy turf growth. To determine what fertilizers and application rates should be recommended, two studies, one by Texas A&M University and the other by the City of Austin, were conducted to understand the impacts of various fertilizers on soil, leachate, and water runoff.

At Texas A&M University researchers conducted a greenhouse study for the City of Austin by analyzing nutrient movement in runoff, leachate, clippings and soil following the application of various fertilizers.

In the second study, the City of Austin is conducting a 5-year experiment in a neighborhood within the contributing watershed to Stillhouse Spring. During this study, plant nutrient concentrations were measured in all yards and fertilizer was given to some homeowners. Also, an education program was conducted in the neighborhood as an effort to reduce the high nutrient levels in Stillhouse Spring. This study will be completed in 2005.

The results to date from these two studies are summarized below.

TEXAS A&M GREENHOUSE STUDY

The Texas A&M Greenhouse Study (see http://www.ci.austin.tx.us/growgreen/greenhouse.htm or References below for detailed information) analyzed the impact of seven types of fertilizers. Of the seven fertilizers used in the study three were organic (Dillo Dirt, 9-1-1, and 8-2-4) and four were inorganic (15-5-10, 13-13-13, 41-0-0, and 21-0-0). (Note: three numbers in sequence used to describe commercially produced fertilizers represent the percentage of nitrate, phosphorus, and potassium in the fertilizer, respectively.)

The Dillo Dirt used in this study was not analyzed, but the average nutrient percentages for Dillo Dirt during the year of the study were 4-3-2. Dillo Dirt, was applied at three different rates: 2 lbs of N per

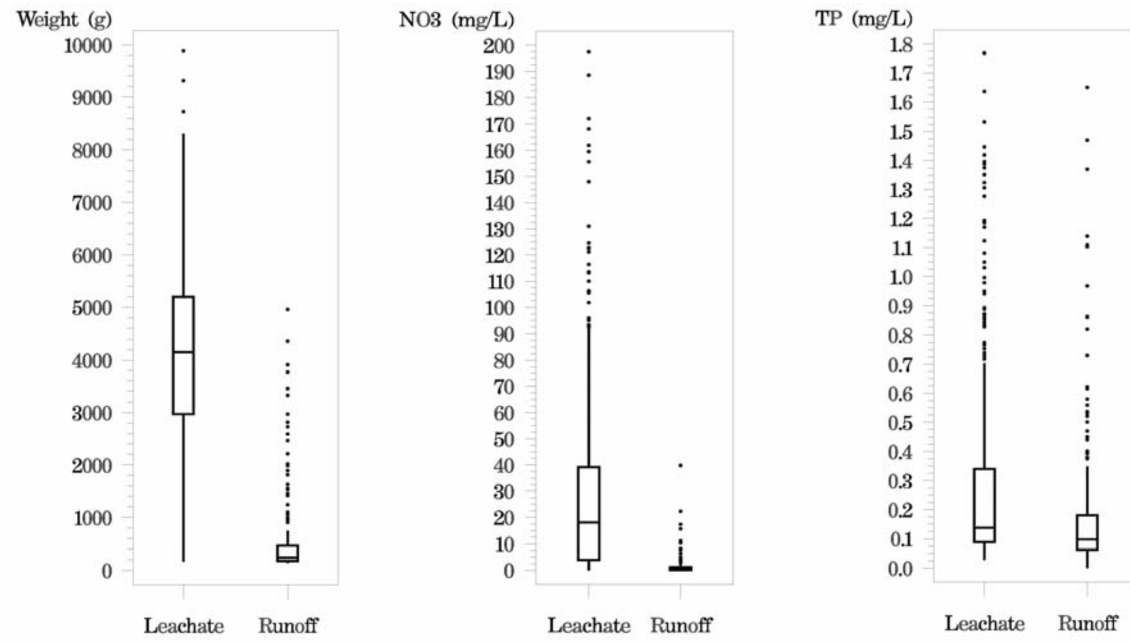
1000 sq. ft., the same as the rest of the fertilizers (denoted as DDN for Dillo Dirt applied on the basis of nitrogen), ½" deep Dillo Dirt on top of the turf (1/2_DD), and 2" of Dillo Dirt incorporated in to the soil prior to the establishment of turf (2_DD).

Two of the inorganic fertilizers, 21-0-0 and 41-0-0, were sustained-release fertilizers.

Each fertilizer except for the ½" and 2" preparations of Dillo Dirt, was applied four times in four months and with simulated rainfall after each fertilization. The two Dillo Dirt preparations were only applied at the start of the study.

Runoff, leachate, clippings, and soil concentrations were measured. The quantity of runoff in this study was much smaller than the leachate volume (see Figure 1). Runoff concentrations were not included in the Texas A&M report, but they are addressed below.

Figure 1. Comparison of leachate to runoff in Texas A&M Greenhouse Study: weight, nitrate, and total phosphorus



Leachate and Runoff

Figure 1 shows that nitrate (NO_3) concentrations found in leachate were much higher than those in runoff, while total phosphorus (TP) concentrations were only slightly higher in runoff than in leachate. The nitrate leachate concentrations are very high compared to the drinking water standard of 10 mg/L and the Austin area creek median level of 0.3 mg/L. The total phosphorus concentrations are not above the drinking water standard, but they are considerably higher than the Austin area creek median level of 0.05 mg/L (COA, 2003).

Nitrate concentrations in leachate and runoff are plotted in Figures 2 and 3. The fertilizers are ordered in the plot from the lowest (left) to the highest (right) mean concentration. Note that organic fertilizers have the lowest mean leachate concentrations. Also, for nitrates found in runoff, some organic fertilizers produced the lowest concentration while other organic types produced the highest concentrations.

Figure 2. Texas A&M Greenhouse Data on NO_3 Concentrations (mg/L) in Leachate from Fertilizer applied to Bermuda Grass

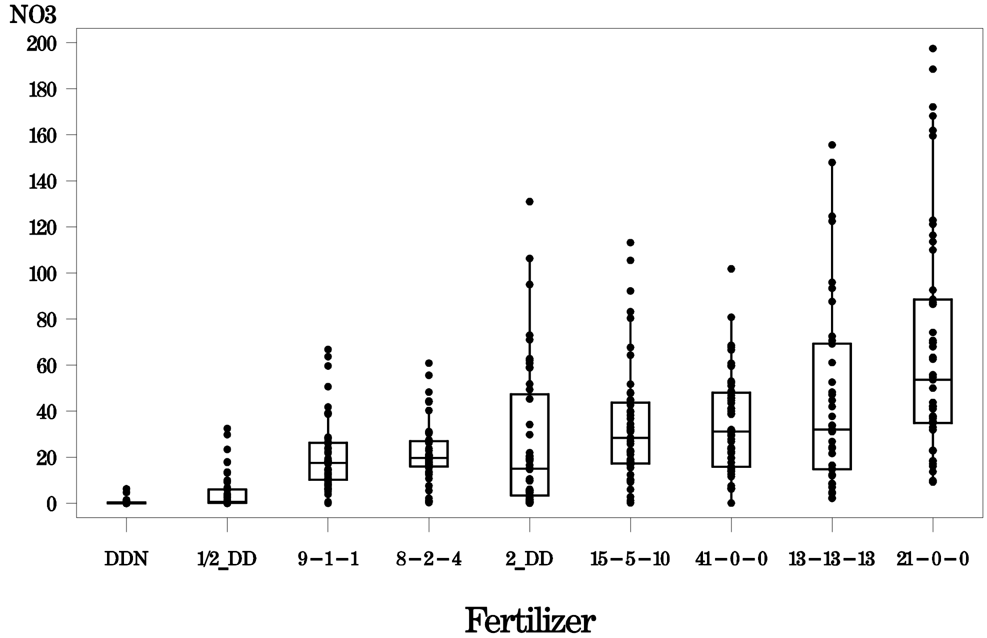
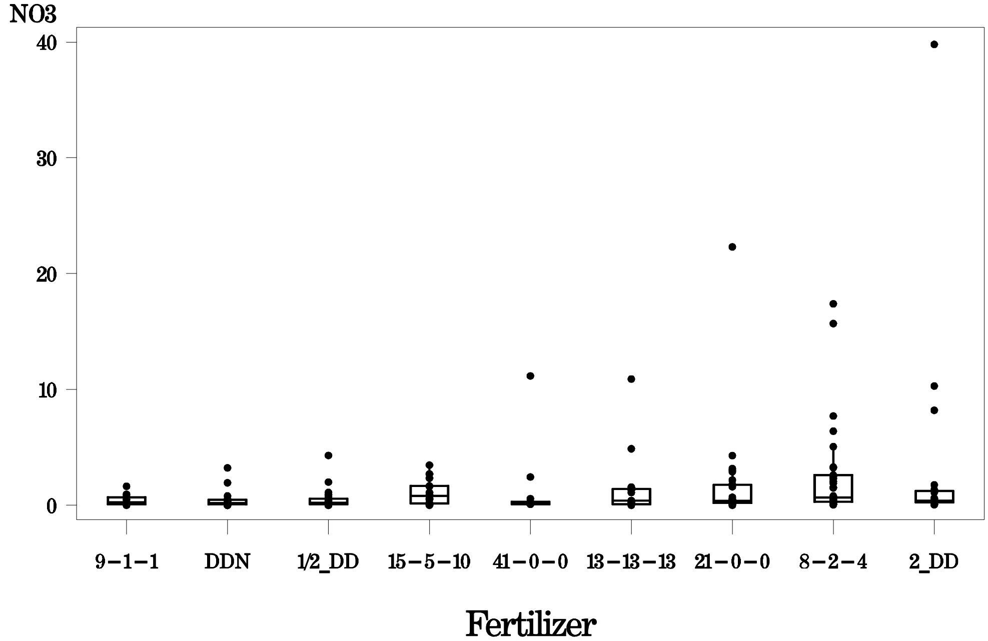


Figure 3. Texas A&M Greenhouse Data on NO_3 Concentrations (mg/L) in Runoff from Fertilizer applied to Bermuda Grass



Total phosphorus concentrations in leachate and runoff are plotted in Figures 4 and 5. For both leachate and runoff, the mean concentrations are directly related to the proportion and amount of phosphorus in the fertilizer. No distinction is found between organic and inorganic fertilizers for phosphorous like that observed in the nitrate data. Both inorganic and organic fertilizer types can have widely varying total phosphorus concentrations.

Figure 4. A&M Greenhouse Data on TP Concentrations (mg/L) in Leachate from Fertilizer applied to Bermuda Grass

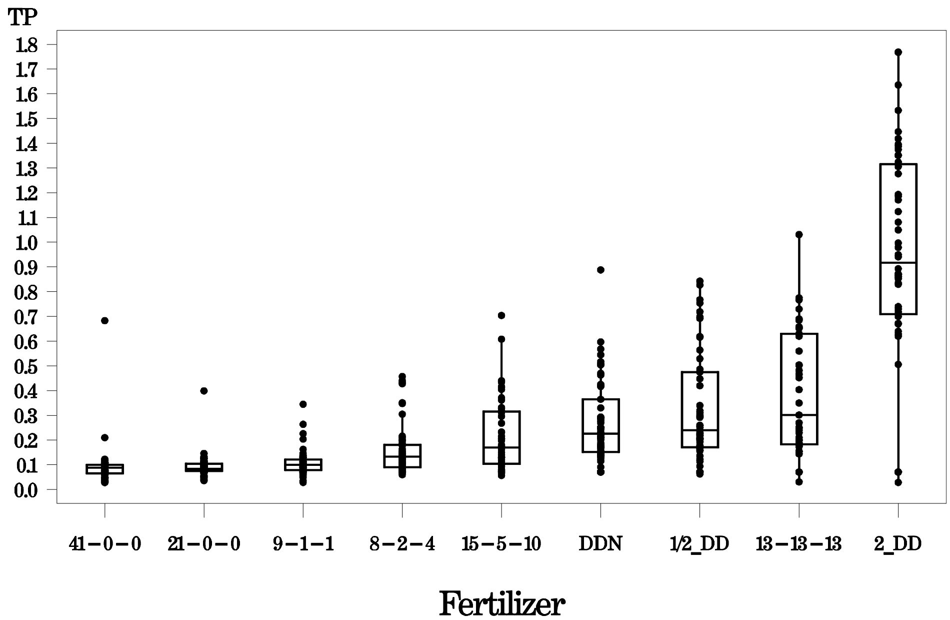
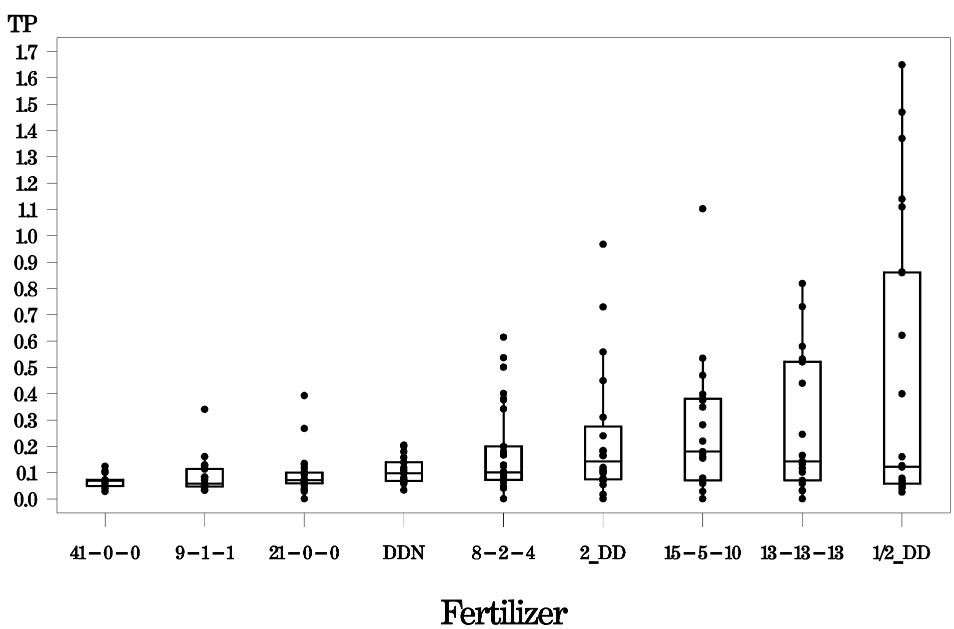


Figure 5. A&M Greenhouse Data on TP Concentrations (mg/L) in Runoff from Fertilizer applied to Bermuda Grass



The study showed that:

- Available phosphorus concentrations are directly related to the proportion and amount of phosphorus in the fertilizer. Final soil nitrate levels are not similarly related.
- No distinction was found between organic and inorganic fertilizers for either available phosphorus or nitrate (see Figures 6 and 7).
- The final soil concentrations are all greater than the initial concentrations, but in the greenhouse study fertilizer was applied more frequently than recommended by our fertilizer application schedule (biannual).
- The final available phosphorus concentrations were highest with the ½" and 2" preparations of Dillo Dirt fertilizers and lowest with 21-0-0, 41-0-0, and 9-1-1.
- The nitrate concentrations were highest with the sustained-release inorganic fertilizers 21-0-0 and 41-0-0 and the 2" Dillo Dirt organic fertilizer, and lowest with ½" Dillo Dirt and DDN.

Figure 6. Texas A&M Greenhouse Data on Final Soil Available Phosphorus Concentrations (mg/Kg) from Fertilizer applied to Bermuda Grass

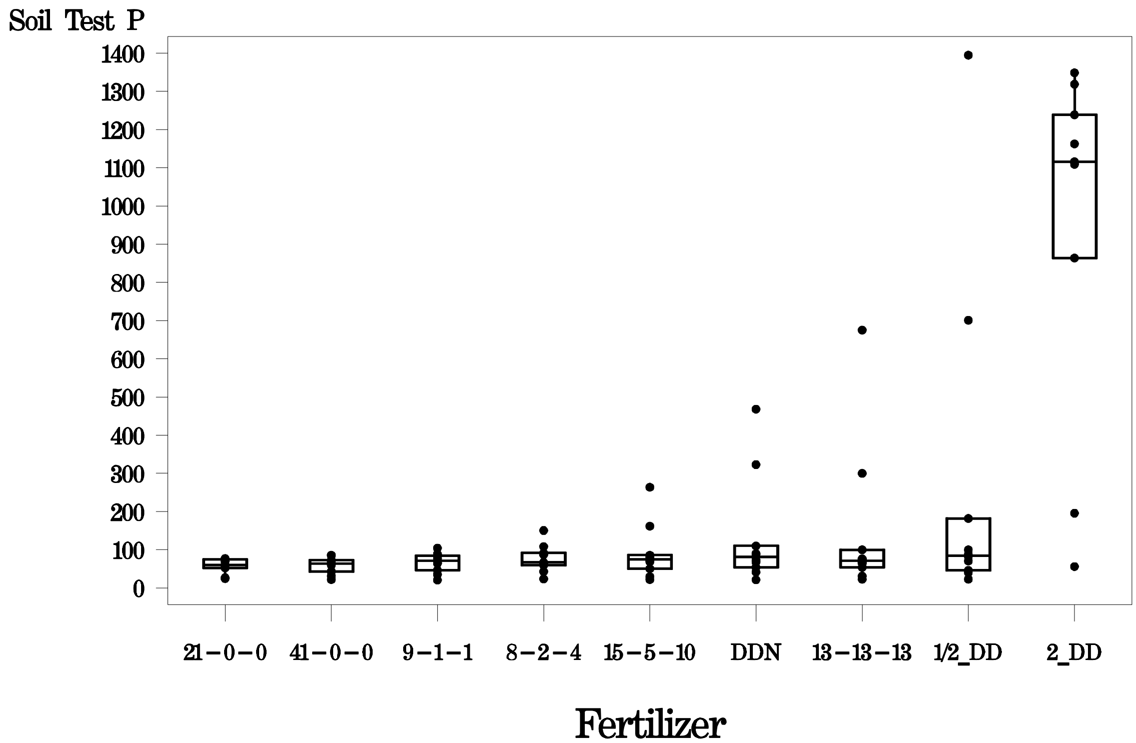
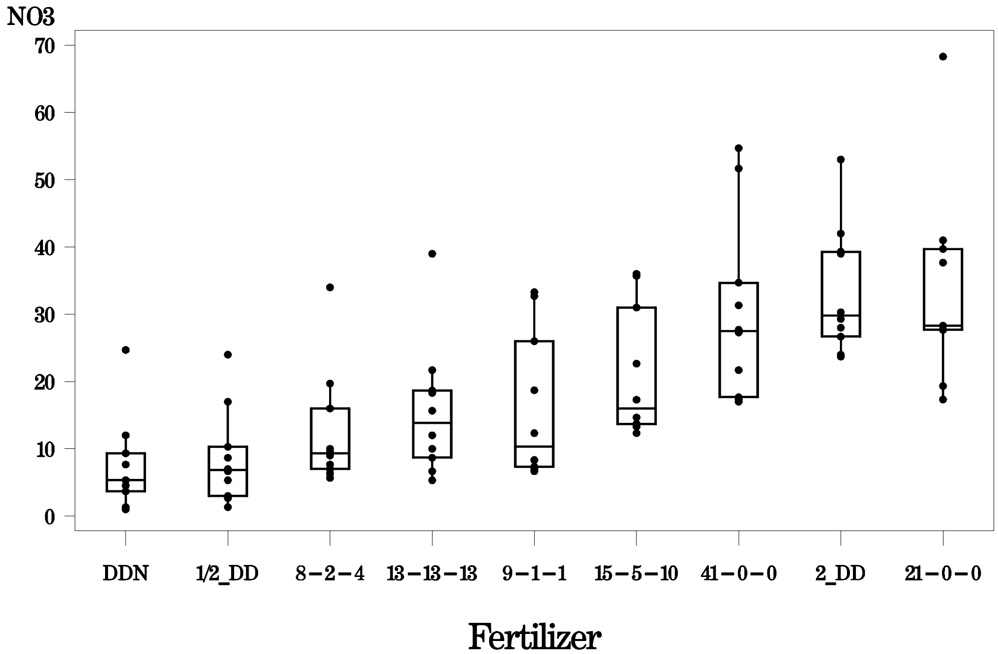


Figure 7. A&M Greenhouse Data on Final Soil Nitrate Concentrations (mg/Kg) from Fertilizer applied to Bermuda Grass



Summary Comparison

Results for nitrate and available phosphorus are summarized with clipping data, salinity, and total Kjeldahl nitrogen in Table 1. The levels are compared to standards or ranking scales where possible. Three areas of concern should be noted:

1. The nitrate leachate concentrations are very high, particularly for the inorganic fertilizers.
2. All fertilizers except for the surface applications of Dillo Dirt have average leachate concentrations above the drinking water standard. DDN is the only fertilizer application with leachate below the aquatic life standard.
3. For most fertilizers, soil concentration of available phosphorus is very high. The highest concentrations found were associated with ½" and 2" Dillo Dirt. High levels of phosphorus in soils may result in iron deficiency, leading to poor plant growth.

Table 1 Summary Results from the A&M Fertilizer Study

		NO3						TKN	Phosphorus						Salinity	Clipping		
		Runoff: creek target=0.1 average=0.3 mg/L		**Leachate:** creek target=0.1 average=0.3 mg/L		**Soil**		**Soil**	**Runoff (TP):** creek target=0.02 average=0.05 mg/L		**Leachate (TP):** creek target=0.02 average=0.05 mg/L		**Soil Available Phosphorus**		**Soil**	**Growth**	**NO3**	**TP**
Fertilizer	Fertilizer Type	Average	Maximum	Average	Maximum	Average Final Soil Concentrations (mg/kg)	Change in soil concentration (mg/kg)	Average Final Soil Concentrations (mg/kg)	Average	Maximum	Average	Maximum	Average Final Soil Concentrations (mg/kg)	Change in soil concentration (mg/kg)	Average Final Soil Concentrations (mg/kg)	Average yield in g/box/week	Average concentrations in mg/gk	Average concentrations in mg/gk
						initial value=2.27 mg/kg							initial value=55 mg/gk					
DDN	Organic	0.5	3.2	0.4	6.3	7.5	20	993	0.11	0.21	0.27	0.89	134	79	237	3	21967	4530
DD_1/2in	Organic	0.5	4.3	4.5	32.5	8.6	6	1514	0.44	1.65	0.33	0.84	273	218	234	4.5	26776	4900
9-1-1	Organic	0.4	1.6	20.5	66.8	16.1	14	883	0.09	0.34	0.11	0.35	67	12	264	5.1	32519	2219
8-2-4	Organic	2.5	17.4	21.7	60.9	12.5	10	879	0.18	0.62	0.16	0.46	76	21	245	6.2	33979	2673
DD_2in	Organic	3.3	39.8	26.3	131.0	33.6	31	3101	0.23	0.97	0.95	1.77	953	898	479	8.8	35045	4085
15-5-10	Inorganic	1.1	3.5	34.2	113.2	21.1	19	849	0.27	1.10	0.21	0.70	92	37	280	4.2	34343	3221
41-0-0	Inorganic	1.2	11.2	34.5	101.8	30.1	28	830	0.07	0.12	0.09	0.68	60	5	269	2.3	32207	2154
13-13-13	Inorganic	1.4	10.9	44.4	155.6	15.6	13	884	0.27	0.82	0.39	1.03	147	92	259	6.7	33960	3437
21-0-0	Inorganic	1.6	22.3	68.2	197.5	34.9	33	849	0.09	0.39	0.09	0.40	58	3	478	3.5	31032	1783

above aquatic life standard of 3.5 mg/L

above drinking water standard of 10 mg/L

very low	0-9
low	10-14
moderate	15-19
high	20-29
very high	>30

highest

lowest

highest

lowest

very low	0-5
low	6-10
moderate	11-41
high	42-61
very high	>62

low	<2.8	<25000	<1900
desired	2.8-3.5	25000-40000	1900-4500
high	>3.5	>40000	>4500

Ranking of Fertilizers

To evaluate the impacts of these fertilizers on the environment, the mean concentration of nitrates (NO_3) and Total Phosphorus (TP) in leachate, runoff, and soil for each fertilizer was compared to the concentrations in each other fertilizer and ranked from the lowest (1) to the highest (9) (see Table 2). The rank values of each fertilizer were then summed and the Sum of Ranks was determined. The fertilizers listed in the table are in the order from the lowest to the highest Sum of Ranks. The fertilizer with lowest Sums of Ranks is the least polluting. However, consideration should also be given to the particular concentration where the maximum rank occurs.

Note that this method of determining the least polluting fertilizers does not consider the severity of the consequences of a given concentration or the size of the difference between concentrations.

Table 2. Ranking of Concentrations Resulting from Fertilizer Application

Fertilizer	Leachate		Runoff		Soil		Sum of Ranks	Maximum Rank
	NO_3	TP	NO_3	TP	NO_3	Soil Test P		
9-1-1	3	3	1	2	5	3	17	5
DDN	1	6	2	4	1	6	20	6
41-0-0	7	1	5	1	7	2	23	7
8-2-4	4	4	8	5	3	4	28	8
½” DD	2	7	3	9	2	8	31	9
21-0-0	9	2	7	3	9	1	31	9
15-5-10	6	5	4	7	6	5	32	7
13-13-13	8	8	6	8	4	7	41	8
2” DD	5	9	9	6	8	9	46	9

Table 2 shows that in general, organic fertilizers are less polluting than inorganic fertilizers.

The organic fertilizer 9-1-1 has the best (lowest) Sum of Ranks score. Its worst rank is for soil nitrate. However, Table 1 shows that the final soil nitrates for 9-1-1 are in the moderate range.

DDN, the surface dusting of Dillo Dirt, ranked second best overall. Its worst rank is in the available soil phosphorus category. Since most soils in Austin are very high in available phosphorus, this aspect could be a serious criticism of DDN. However, recent Dillo Dirt ratios (9-2-1 in 2002) are lower in phosphorus than during the year of the study (4-3-2 in 2001), and may not cause a significant increase in soil phosphorus levels.

The third best fertilizer is 41-0-0. However, it ranks the highest in nitrate leachate, with an average leachate 3½ times the drinking water standard and a maximum value 10 times the standard. These high nitrate levels are a potential problem for aquifer-dwelling amphibians, as well as to other aquatic life. The sustained-release mechanism for this fertilizer does not appear to work in the high temperatures of the Austin climate. Arguably, this fertilizer should not be used. If this fertilizer was redesigned for high temperature use, then it should be reconsidered.

The worst score is for 2" of Dillo Dirt incorporated into the soil at the start of the study. It is possible that if this fertilizer was applied once with no additional applications for an extended period, the total pollutant load would be less than that of other fertilizers that appear better in this comparison. However, Dillo Dirt is recommended by agronomists to be applied biannually for residential turf grass. The basis for this recommendation should be evaluated in light of the results of this study.

Conclusion

Data from the Texas A&M Greenhouse Study indicate that among the products tested organic fertilizers with the lowest proportion of phosphorus should be recommended.

CITY OF AUSTIN STILLHOUSE STUDY

Nitrate concentrations averaging 6.6 mg/L as N were found in Stillhouse Spring. These concentrations are abnormally high for the Austin area, and are above the aquatic life standard of 3.5 mg/L of NO_3 as N. Additionally, deformed and sluggish salamanders were found below the spring.

It was suspected that fertilizer used in the Stillhouse Spring watershed area was responsible for the high nitrate concentrations. Therefore, with the goal to reduce the nutrient concentrations, the neighborhood from which infiltrated water could contribute to the spring's high nutrient concentration was targeted for environmental education.

In 2001, the City of Austin initiated a 5-year study (Stillhouse Study) to assess the impact of different fertilizers on the nitrate and phosphate levels in the soil of the Stillhouse neighborhood and the effect on Stillhouse Spring. In the study, a fertilization education program was conducted, gifts of fertilizer were given in the spring and fall of the year to homeowners who requested them, and soil samples were taken from yards in the winter to measure nitrates and phosphates. Fertilizers were distributed as follows:

- In 2001, the fertilizer gifts included ½" Dillo Dirt, 21-0-0, and 8-2-4 with 21-0-0 being the most frequently used fertilizer.
- In 2002, the most frequently used fertilizer was 8-2-4, since the results of the Texas A&M Greenhouse Study indicated that using organic fertilizers resulted in lower nitrate leachate concentrations.
- In 2003, Dillo Dirt was applied ¼" deep on several yards to determine if increases in available soil phosphorus could be prevented while maintaining the benefits of nitrogen leachate concentrations below the drinking water and aquatic life standards.

At Stillhouse Spring, groundwater was monitored to see if changes in fertilization habits through education and gifts of fertilizer reduced the spring's nitrate concentrations.

In this report, the soil sample data from 2001 through the beginning of 2003 are discussed. Also, soil concentrations of nitrates and phosphorus and changes in soil nutrient levels related to different fertilizer applications are presented.

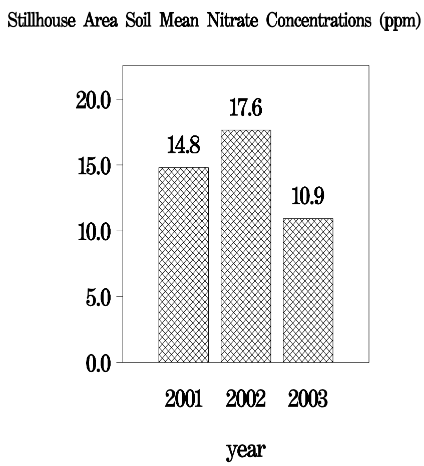
Soil levels

Soil scientists rank soil nutrient levels by the amounts needed for plant growth. These levels are specified in Table 3. The average soil nutrient levels in the Stillhouse neighborhood in January of 2001, 2002, and 2003 are shown in Figure 8.

Table 3. Soil Nutrients Level relative to Plant Growth Needs

Rank	Nitrate in Soil (mg/Kg)	Soil test P (mg/Kg)
Very low	0-9	0-5
Low	10-14	6-10
Moderate	15-19	11-41
High	20-29	42-61
Very high	>30	>62

Figure 8 Average Soil Nutrient Levels in the Stillhouse Neighborhood in January 2001, 2002, and 2003



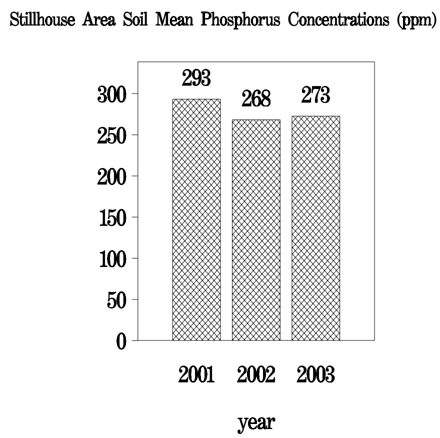
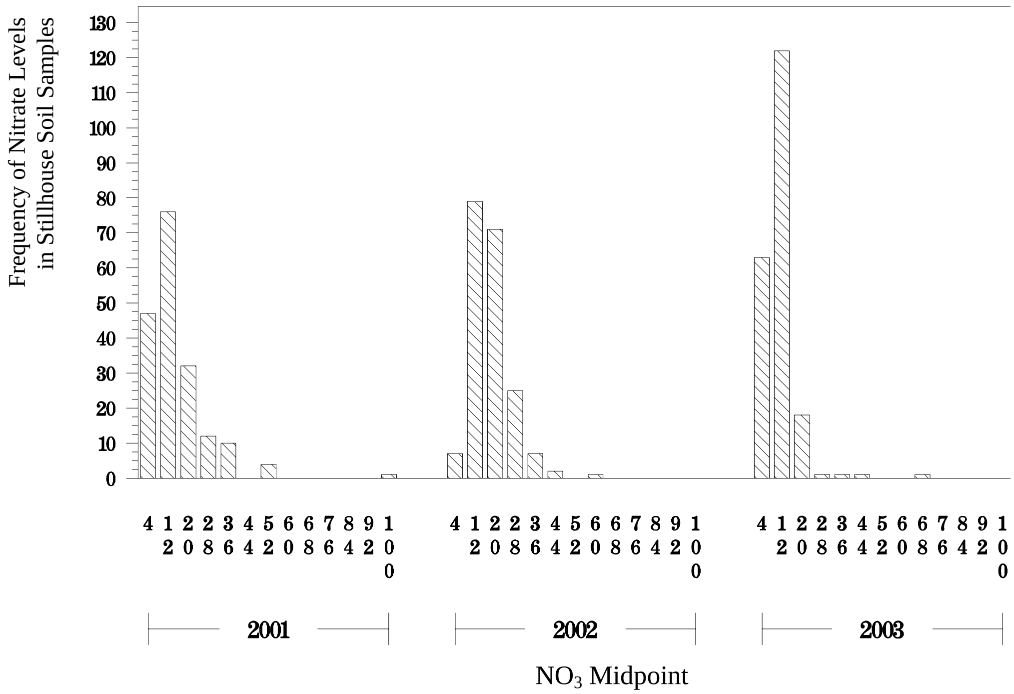


Table 3 and Figure 8 show that the average nitrate levels are in either the low or moderate rank, while the available phosphorus levels are very high. Note that available phosphorus concentrations declined slightly (7%) during the period, while nitrate levels increased in 2002 and decreased in 2003. These changes are most likely due to the types of fertilizer given to selected homes in the Stillhouse neighborhood. Figures 9 and 10 chart the frequency distributions of these nutrients.

In 2001 the most common type of fertilizer gift was 21-0-0, whereas in 2002, it was 8--2--4. With the application of 21-0-0, nitrate soil levels are expected to increase coupled with a decrease in available phosphorus levels. When 8-2-4 is applied, the nitrate levels are not as high, but the available phosphorus levels are higher.

Figure 9. Frequency Distributions of Nitrate Levels in Stillhouse Soil Samples during 2001 through 2003



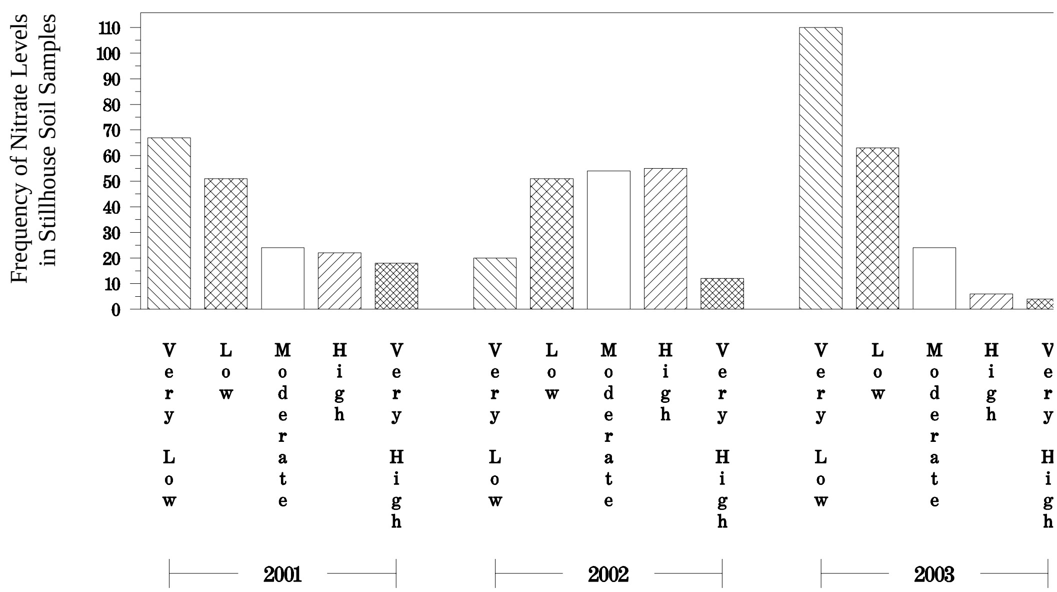
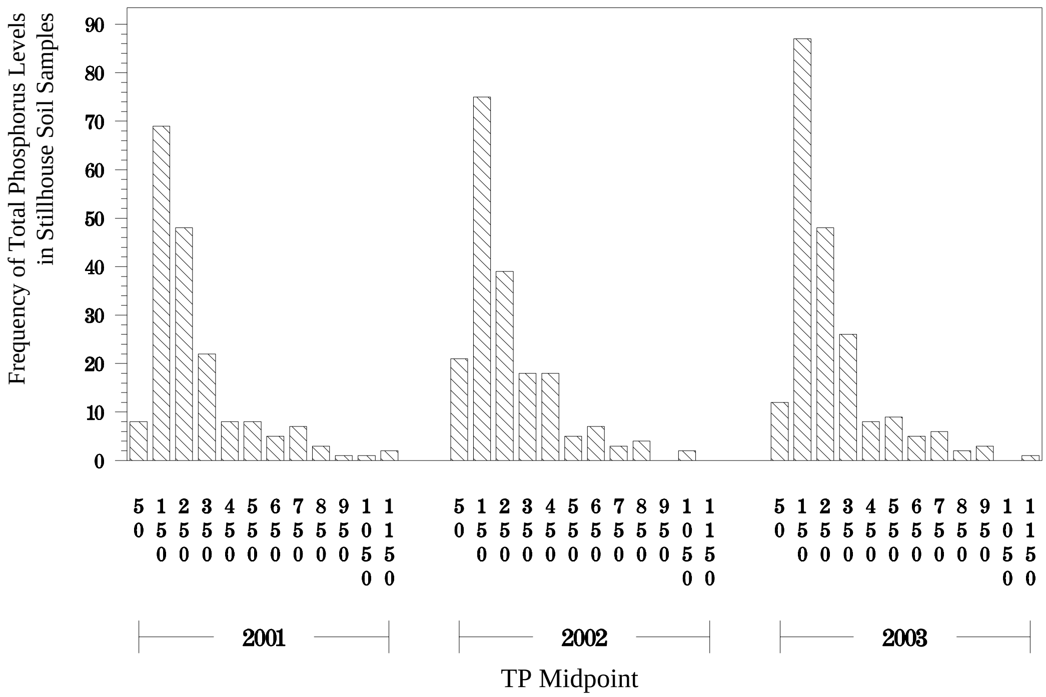
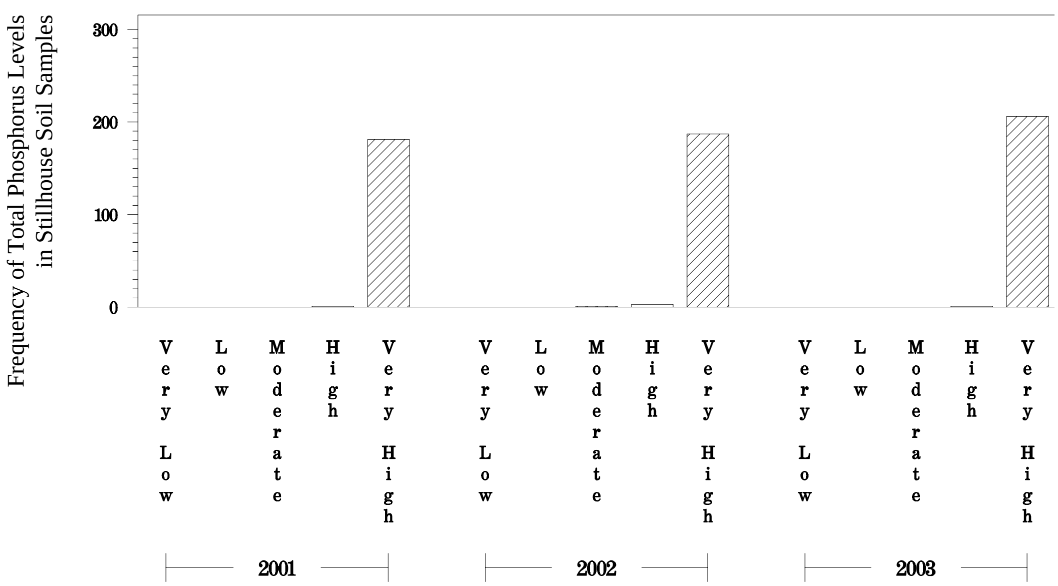


Figure 10. Frequency Distributions of Available Phosphorus Levels in Stillhouse Soil Samples during 2001- through 2003





Change in soil nutrient levels with fertilizer gifts

To analyze the effects of various fertilizers on soil nutrient levels the mean change in soil nutrient levels for every category of fertilizer used during 2001 and 2002 were plotted. See Figures 11 and 12. During the study:

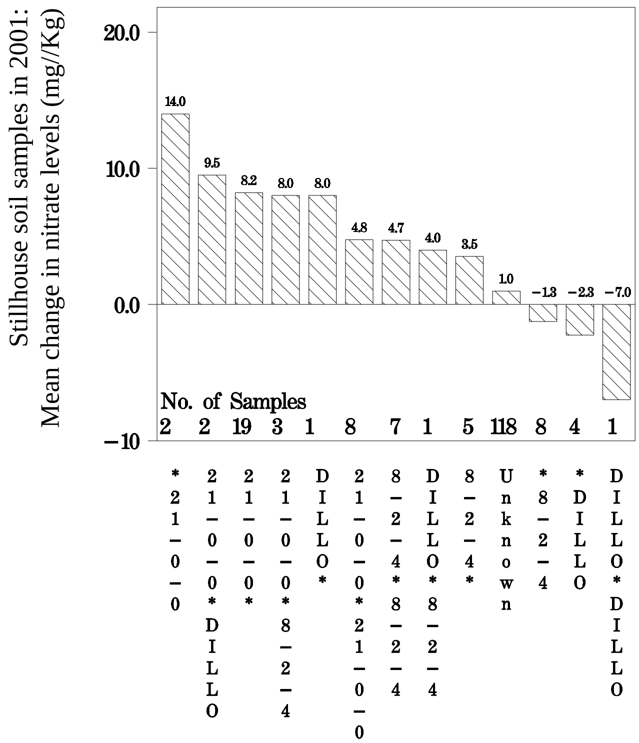
- Dillo Dirt was spread ½" deep in 2001 and 2002.
- Fertilizer was given to some homeowners in both the spring and the fall (this category is labeled (*spring fertilizer)**(*fall fertilizer)*). In many cases fertilizer was given to homeowners in only one season (these categories are labeled either (*spring fertilizer)** or *(*fall fertilizer)*).
- The majority of the homeowners did not participate in the fertilizer give-away (this category is labeled "*" or "Unknown"). The results in this category for the two years are not necessarily the same.
- Other factors, such as annual rainfall, may also affect soil nutrient levels.

Significant differences in soil nutrient levels with different fertilizers

Data from 2001 and 2002 were combined for the fertilizers 8-2-4, 21-0-0 and ½" Dillo Dirt. Other categories have insufficient data. The fertilizer groups *8-2-4, 8-2-4*, and 8-2-4*8-2-4 were combined and labeled 8-2-4. 21-0-0*, *21-0-0 and 21-0-0*21-0-0 were also combined and labeled 21-0-0. Similarly, *½" Dillo Dirt, ½" Dillo Dirt* and ½" Dillo Dirt*½" Dillo Dirt were combined and labeled Dillo.

Analysis of variance was used to test for significant differences in the change in soil nutrient levels. See Figure 13. This analysis shows that the change in soil nitrate is significantly higher with 21-0-0 than with 8-2-4 or ½" Dillo Dirt. Additionally, the change in available soil phosphorus is significantly higher with ½" Dillo Dirt than with 8-2-4 or 21-0-0. Notice that when 8-2-4 was applied, the average soil levels decreased for both nitrate and available phosphorus. The ½" Dillo Dirt and 21-0-0, however, resulted in increases for nitrates and decreases of available phosphorus.

Figure 11. The Annual Mean Change in Nitrate Levels in Stillhouse Soil Samples during 2001 and 2002



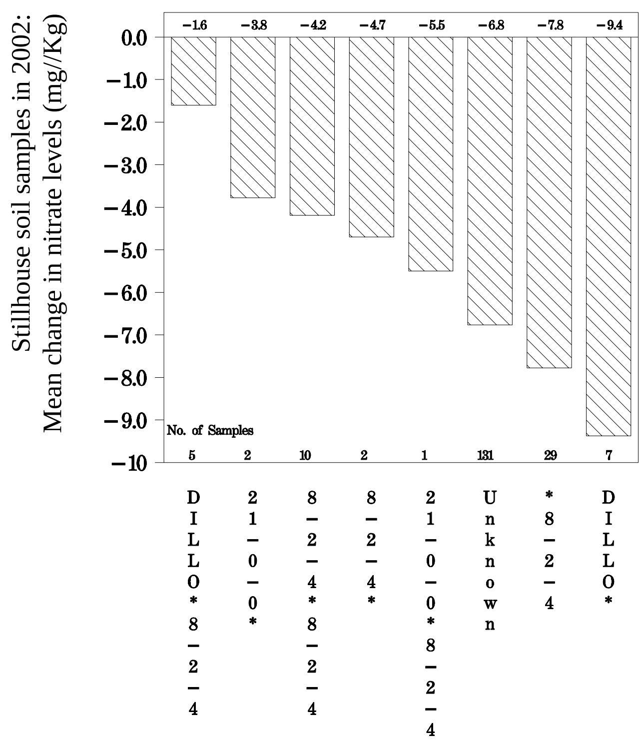
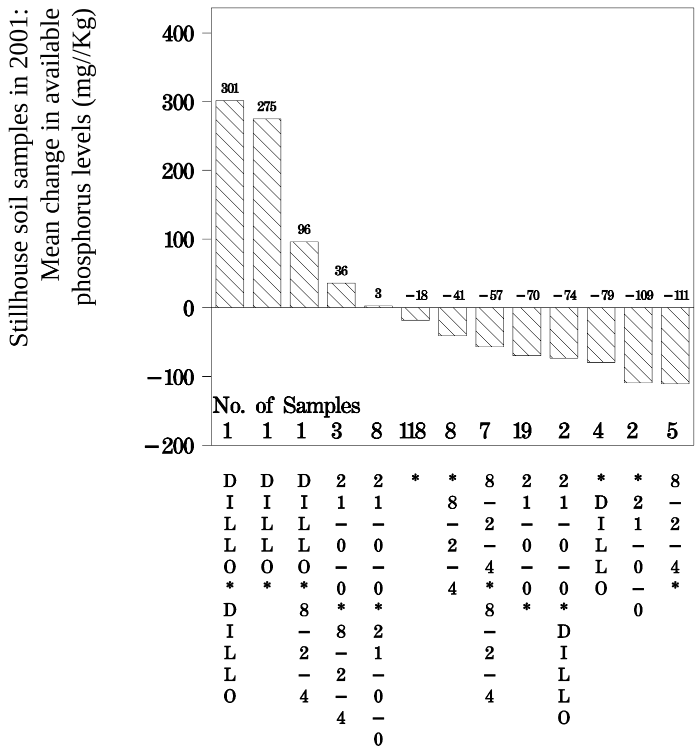


Figure 12. The Annual Mean Change in Available Phosphorus Levels in Stillhouse Soil Samples during 2001 and 2002



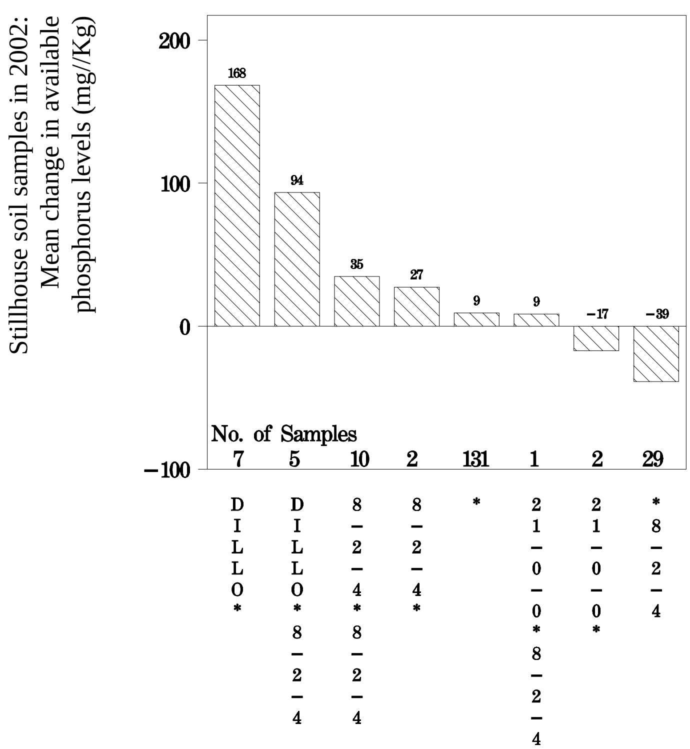
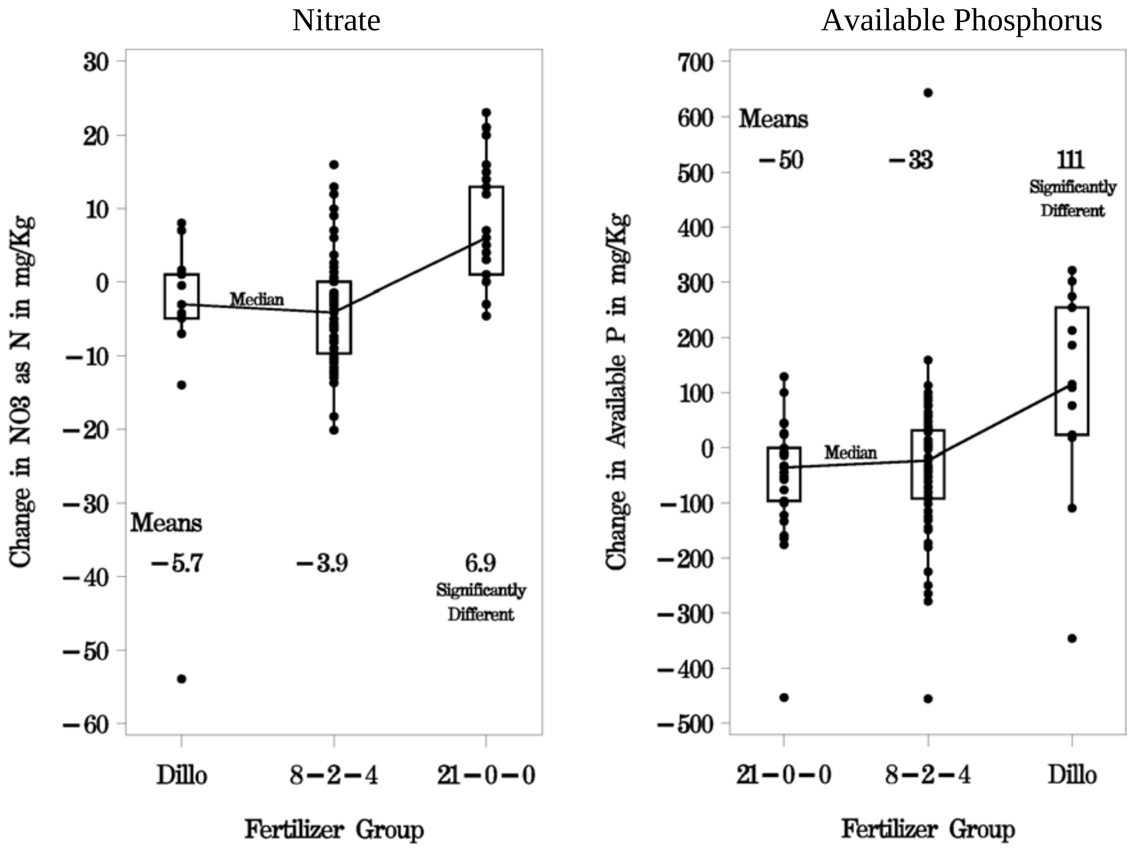


Figure 13. Annual Change in Soil Nutrient Concentrations for three Fertilizers: 21-0-0, 8-2-4, and ½" Dillo Dirt



Conclusions

When 8-2-4 was applied, the average soil nitrate and available phosphorus levels decreased. For both nitrate and available phosphorus, 8-2-4 was statistically equivalent to the fertilizer with the largest decrease in soil concentration. Both ½" Dillo Dirt and 21-0-0 resulted in increases for one nutrient and decreases for the other. Thus, of the three fertilizers with sufficient data, 8-2-4 is the best choice to minimize the pollution of area springs and creeks due to lawn fertilization.

SUMMARY CONCLUSIONS FROM BOTH STUDIES

Tables 4 and 5 summarize the potential impacts of nitrogen and phosphorus in fertilizer on soil, groundwater, and storm water runoff, using both the Texas A&M data and data from various COA studies. Preliminary conclusions from the two studies are:

- Austin area soils have very high levels of available phosphorus and moderate levels of soil nitrate.
- Nitrate leachate from most fertilizers is very high relative to drinking water and aquatic life standards.
- Organic fertilizers are better overall than inorganic fertilizers, particularly with respect to nitrate leachate.

- Organic fertilizers should have a low proportion of phosphorus - the lower the better.
- 9-1-1 ranked the best of the nine fertilizers tested in the Texas A&M Greenhouse Study. Runoff, leachate, and soil nutrient concentrations were considered in this study.
- 8-2-4 was better than 21-0-0 and ½" Dillo Dirt in the COA Stillhouse Study. Only soil nutrient concentrations were measured.
- Further study is needed for thinner applications of Dillo Dirt. The ¼" Dillo Dirt was applied in 2004 and additional analysis will be performed on these data.

Table 4. Effects of Nitrogen from Fertilizer on Runoff, Soil and Leachate Concentrations

Nitrate from Fertilizer						
Medium	**Soil**		**Leachate**		**Runoff**	
time frame	long term		short and long term		short term	
Target	< 20 mg/kg (moderate); [initial study level = 2.3 mg/kg (low)]		stream: 0.1 mg/L good, 0.3 mg/L average Spring/Aquifer < 3.5 mg/L (Aquatic Life Standard, 10 = drinking water standard)		stream: 0.1 mg/L good, 0.3 mg/L average Spring/Aquifer < 3.5 mg/L (Aquatic Life Standard, 10 = drinking water standard)	
A&M Greenhouse Study	Fertilizer	Mean Change in Concentration (mg/kg)	Fertilizer	Concentration (mg/L asN)	Fertilizer	Concentration (mg/L as N)
	Dillo surface application	6, 20	Dillo surface application	0.4, 4.5	Dillo surface application	0.5,0.5
	other organic	10, 14, 31	other organic	20, 22, 26	other organic	0.4, 2.5, 3.3
	inorganic	13, 19, 28, 33	inorganic	34, 34, 45, 68	inorganic	1.1, 1.2, 1.4, 1.6
COA Stillhouse Study	Fertilizer	Mean Change in Concentration (mg/kg)				
	1/2" Dillo	-5.7				
	8-2-4	-3.9				
	21-0-0	6.9				
Current Conditions	range from very low to very high, mean is low to moderate		Stillhouse Spring mean = 6.6 mg/L [6.6 mg/L is 66 times the target of 0.1 mg/L and 22 times the median of 0.3 mg/L] [6.6 is approximately 1/4 of average leachate]		Stormwater: Shoal Creek 0.66 mg/L, Williamson 0.42 mg/L	
Consequence of fertilizer program	Soil levels will increase if 21-0-0 is used; otherwise they will decrease. .		Dillo dirt application should decrease spring concentrations. Other fertilizers may increase spring concentrations. Current concentrations are above the aquatic life standards. High nitrate concentrations increase the growth of algae in creeks and lakes. Most BMPs do not do a good job at removing nitrate.		If recommendations for time of application and watering are followed stormwater concentrations should decrease.	

Table 5. Effects of Phosphorus from Fertilizer on Runoff, Soil and Leachate

Total Phosphorus from Fertilizer						
Medium	**Soil**		**Leachate**		**Runoff**	
time frame	long term		short and long term		short term	
Target	< 42 mg/kg (moderate); initial study level = 414 mg/kg (very very high)		stream PO4 as P: 0.02 mg/L good, 0.05 mg/L average		stream PO4 as P: 0.02 mg/L good, 0.05 mg/L average stream TP as P: 0.04 mg/L good, 0.10 mg/L average	
A&M Greenhouse Study	Fertilizer	Mean Change in Concentration (mg/kg)	Fertilizer	Concentration (TP as P in mg/L)	Fertilizer	Concentration (TP as P in mg/L)
	Dillo surface application	165, 635	Dillo surface application	0.27, 0.33	Dillo surface application	0.11, 0.44
	other organic	9,31,2092	other organic	0.11, 0.16, 0.95	other organic	0.09, 0.18, 0.23
	inorganic	-22, -18, 47, 108	inorganic	0.09, 0.09, 0.21, 0.39	inorganic	0.07, 0.09, 0.27, 0.27
COA Stillhouse Study	Fertilizer	Mean Change in Concentration (mg/kg)				
	1/2" Dillo	111				
	8-2-4	-33				
	21-0-0	-50				
Current Conditions	almost all soils are very, very high		Stillhouse Spring mean =0.12 mg/L of PO4 as P, 0.14 mg/L of TP [0.12 mg/L is 6 times the target of 0.02 mg/L and 2.4 times the median of 0.05 mg/L] [0.12 is approximately 1/2 of average leachate]		Stormwater : Shoal Creek 0.54 mg/L of PO4 as P (1.08 mg/L of TP), Williamson 0.21 mg/L of PO4 as P (0.42 mg/L of TP)	
Consequence of fertilizer program	Soil levels will increase if 1/2" Dillo dirt is used, otherwise they will decrease. With high TP levels, iron may not be available and yellowing can occur leading to excess fertilizer application		Spring levels may not change, but current levels are high. These levels can cause excessive alge growth in streams and eutropication (>0.04 mg/L of PO4 as P) in lakes.		if recommendations for time of application and watering are followed stormwater concentrations should decrease	

In the Texas A&M Greenhouse Study, every fertilizer produced increases in both soil nutrient levels, some of which were quite large. In the COA study, increases in soil nutrient levels due to fertilization were considerably smaller than the changes observed during the Texas A&M Greenhouse Study, and in some cases, there were decreases instead of increases. Thus the Texas A&M Greenhouse Study shows the relative ranking of fertilizer impacts on soil nutrient concentrations but is not a good predictor of the actual change in nutrient concentration in Austin's soil.

REFERENCES

City of Austin, 2003. Unpublished water quality data from Water Resourced Information System. Watershed Protection and Development Review Department, Environmental Resource Management Division, Field Sampling Database.

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