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Contributions of Nitrogen and Phosphorus to Surface and Groundwater from a Kentucky Bluegrass Lawn

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INTRODUCTION

A common public perception is that fertilizer applied to home lawns is a major contributor of nitrogen and phosphorus to surface water and of nitrate-nitrogen to groundwater. Algal blooms on urban lakes and high nitrate concentrations in groundwater are often blamed on lawn fertilization.

Research done elsewhere in the U.S. has indicated that lawns are not major contributors of nitrogen and phosphorus to the environment. In 1991, I decided to test whether or not this was true in the Madison area.

METHODS

Research plots were set up to simulate urban conditions. The topsoil was stripped off, the subsoil compacted, and then the topsoil replaced. The area was seeded to a four-way blend of Kentucky bluegrasses. Devices to collect runoff water and leachate were then installed.

The plots have been fertilized each year with 4.0 lb nitrogen/1,000 ft^2 split into four equal applications of 1.0 lb nitrogen. The application dates were approximately May 15, July 1, September 15, and October 20. The plots were mowed at 2 ½ inches every 4 to 7 days. Irrigation water was applied when the grass became bluish-green in color, indicating moisture stress.

RESULTS

<u>1993 and 1994</u>

During this period, the objective was to see how the subsoil compaction resulting from building construction and the layering of topsoil over compacted or uncompacted subsoil affects the amounts of runoff water and losses of nitrogen and phosphorus. What I found was:

1. The amount of runoff water averaged 1.35 inches per year and 73% of this was collected when the soil was frozen.

2. Nitrogen in the runoff water averaged 0.24 pound per acre. Runoff during the winter and from snow melt contributed 59% of this nitrogen.
3. Phosphorus in the runoff water averaged 0.32 pound per acre and 66.8% of this was collected when the soil was frozen.
4. The amount of leachate averaged 18.03 inches per year. This leachate contained an average of 2.2 pounds nitrogen per acre per year and had an average nitrate- nitrogen concentration of 2.74 parts per million (ppm).
5. Soil disturbance in the form of subsoil compaction and topsoil layering did not significantly alter the amounts of runoff water, the amounts of nitrogen and phosphorus in the runoff water, or the amount of nitrogen leached.

1995 and 1996

The treatments during this 2-year period were selected to show how the amounts of runoff water and nutrient losses were affected by:

1. Lawn fertilization — none vs. 4 lb nitrogen per year.
2. Type of fertilizer — natural organic vs. synthetic.
3. Clipping management — mulch mowing vs. clipping removal.

Data collected from this 2-year period showed that:

1. The amount of runoff water was 1.32 inches per year and 72% came from frozen soil — almost the same as in 1993 and 1994.
2. Nitrogen loss in the runoff water averaged 0.29 pound per acre per year. Runoff water from frozen soil contained 72% of the total nitrogen.
3. Phosphorus loss in the runoff water averaged 0.30 pound per acre per year and 80.6% of this came from frozen soil.
4. The amount of leachate totaled 11.80 inches per year and contained, on average, 2.6 pounds nitrogen per acre. Nitrate-nitrogen concentration averaged 1.60 ppm.
5. Not fertilizing the lawn for 2 years caused the turf to thin out to the point where the amount of runoff water was 30% more than where fertilizer was applied.
6. Nitrogen and phosphorus in the runoff water from the unfertilized turf exceeded that from the fertilized turf by 24% for nitrogen and 41% for phosphorus.
7. The amounts of nitrogen and phosphorus in runoff water and nitrogen in leachate were the same whether the fertilizer applied was natural organic or synthetic.
8. As compared to where clippings were removed, mulch mowing slightly decreased the amount of runoff water but increased by 2.1 pounds per acre the amount of nitrate-nitrogen in the leachate.

1997 and 1998

This 2-year period was devoted to testing the effect of form of nitrogen in lawn fertilizer on nitrogen in runoff water and leachate. The form of nitrogen ranged from urea, which is 100% water-soluble to several forms of slow-release nitrogen to 100% natural organic nitrogen. Observations during this 2-year period were:

1. The amount of runoff water per year was 1.24 inches, or 0.08 to 0.11 inch less than in the four previous years, but the portion from frozen soil was 95.2%, or more than 20% greater than in 1993 through 1996.
2. With 20% more of the runoff water coming from frozen soil, the amount of nitrogen it contained increased 125% to 0.6 pound per acre per year, of which 94.3% was from frozen soil.
3. The amount of phosphorus in the runoff water also increased — from an average of 0.31 to 0.45 pound per acre per year and 96% of this came from frozen soil.
4. Leachate for this period averaged 14.99 inches. The leachate contained 1.85 pounds nitrogen per acre per year and the nitrate-nitrogen concentration averaged 1.60 ppm.
5. The amounts of nitrogen and phosphorus detected in the runoff water and leachate were not influenced by the form of nitrogen applied.
6. The amount of phosphorus in the runoff water did not vary among the fertilizer treatments even though the amount of phosphorus applied ranged from 0 to 25 pounds per acre per year.

SUMMARY

Six years of data were collected from a Kentucky bluegrass lawn established on silt loam soil disturbed in the same manner as in an urban area. The site had a 5.5% slope. The amount of runoff water collected averaged 1.30 inches per year. This amounts to 4.2 % of the long-term annual average precipitation in the area of 30.9 inches. On average, 80.1% of the annual runoff occurred when the soil was frozen.

Leachate collected averaged 14.94 inches per year and accounted for 48.3% of average annual precipitation. For the 6-year period, 11.5 times more water was collected as leachate than as runoff water.

Annual losses of nitrogen and phosphorus in the runoff water averaged 0.33 and 0.36 pound per acre, respectively. Seventy-five percent of this nitrogen and 81% of this phosphorus was in runoff collected when the soil was frozen.

Leachate nitrogen averaged 2.25 pounds per acre per year, which is nearly six times the amount of nitrogen lost in the runoff water. All but a trace of nitrogen in the leachate was in the form of nitrate. Leachate nitrate-nitrogen concentrations annually averaged 1.92 ppm for the 6-year period.

DISCUSSION

To fully comprehend and appreciate the results of this 6-year study, they have to be placed in some kind of context. Watersheds that supply the phosphorus associated with lake eutrophication and contamination of groundwater with nitrate typically encompass rural as well as urban areas. Therefore, there is logic in comparing the nitrogen and phosphorus losses observed in this study to losses from agricultural land.

Several long-term research projects that have been conducted in the Midwest provide a comprehensive perspective of what can be expected in terms of runoff water, erosion, and nutrient losses from agricultural land. These studies have shown that:

1. The amounts of runoff water from farm fields during the growing season typically range from about 5 inches for a row crop to 2 inches for hay or pasture. I measured an average of 1.3 inches of runoff water per year, with only about 0.25 inch being lost when the soil was not frozen.
2. Annual sediment loss, if controlled with conservation practices, ranges from 5 to 7 tons per acre for row crops to as little as 0.1 ton for pasture. In the present study, sediment losses were too low to measure accurately, but other researchers have recorded losses that average about 0.005 ton per acre.
3. Nitrogen losses in runoff water from cropland may range anywhere from 4 to 20 pounds per acre per season, while phosphorus losses average about 10 pounds per acre. Comparable numbers from my study were 0.38 pound of nitrogen and 0.36 pound of phosphorus for the entire year. Losses from non-frozen soil were in the range of 0.1 pound nitrogen and 0.07 pound phosphorus per acre.
4. The amount of nitrogen leached from agronomic crops has been reported to be in the range of 21 to 67 pounds per acre per season. This is in sharp contract with the 6-year average of 2.25 pounds nitrogen per acre per year that I measured.
5. Nitrate-nitrogen concentrations averaged over the season from agronomic crops have been reported to be in the range of 12 to 20 ppm. My average concentration was 1.9 ppm of nitrate-nitrogen. Other researchers have found even lower values for turf.

From these numbers it appears that rationally managed turfgrass, when compared to agronomic crops, yields only about 5% as much runoff water during the growing season, contributes less than 1% as much sediment, nitrogen and phosphorus in the runoff water, allows only 10% as much nitrogen to leach, and maintains leachate nitrate-nitrogen concentrations that are but 15% or so those for agronomic crops.

I observed that 75 to 80% of the nitrogen and phosphorus in runoff water exited the Kentucky bluegrass when the soil was frozen. The question raised by this observation is the source of this nitrogen and phosphorus. There are multiple studies that clearly indicate that this nitrogen and phosphorus are being leached out of the frozen, desiccated turfgrass. The same holds true for all other types of vegetation in the landscape and explains why phosphorus concentrations in storm sewer water show a minor peak at the time of leaf fall and a major peak in snow melt. It also explains why the ratio of nitrogen to phosphorus I measured in the runoff water was nearly 1:1 and not even close to the 14:1 ratio of nitrogen to phosphorus in the fertilizer applied over the 6 years of the study.

CONCLUSIONS

The public perception that lawns and lawn fertilizers are major contributors of nitrogen and phosphorus to lakes, streams, and groundwater is false. Their contributions are overshadowed by those from agricultural lands.

The notion that banning of phosphate application on home lawns will significantly reduce lake eutrophication is likewise false. With 6 years of data in hand, I examined the relationship between runoff losses of phosphorus and the rates of fertilizer phosphate applied. For all practical purposes, there was no relationship. As long as we maintain green landscapes, there will be a relatively small but fairly consistent release of phosphorus into urban surface water from that vegetation regardless of whether fertilizer is applied or not. Failure to maintain quality turf through fertilization carries the risk of increasing amounts of runoff in urban environments.

These conclusions should by no means serve as a green light to indiscriminately and irresponsibly apply fertilizer on home lawns. It is irresponsible to apply more nitrogen than required to maintain an attractive lawn and to apply phosphate and potash when they are not needed. It is even more irresponsible not to clean up fertilizer misapplied to impervious surfaces.