Turfgrass and Environmental Research Online

...Using Science to Benefit Golf

Colbert Hills Golf Course, Manhattan, KS, provided the venue for researchers at Kansas State University to study the effectiveness of detention ponds to attenuate pesticide runoff from golf course fairways.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Roundup Runoff from Zoysiagrass Fairways

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SUMMARY

Maintaining good surface water quality requires best management practices to be used for every stakeholder to minimize the pollutant loading to streams. The goal of this research at Kansas State University was to determine pesticide runoff from golf course-dominated watershed and to determine the effectiveness of detention ponds to manage pesticide runoff from an operating golf course. Findings include:

- Soil samples were taken around each fairway drain to determine the partitioning of pesticides between soil and water. Sediment samples from the bottom of the pond were also taken on an annual basis. Samples of the pond water were taken every month. There were seven locations in the pond where samples were taken at three different depths (25%, 50%, and 75% of the total depth of the water in detention pond).
- Tests determined the concentration of glyphosate (Roundup), aminomethylphosphonic acid (AMPA), which is a degradation product of glyphosate, and glufosinate, which is a product similar to Roundup.
- All of the tests conducted thus far have shown levels of glyphosate much lower than the limits listed in the glyphosate MSDS. The highest reading has been 22 ppb for AMPA. This is also below the risk levels from the MSDS for AMPA. There have not been any pesticides detected in any of the tested pond samples. The detention pond has done an excellent job in diluting and breaking down the pesticide concentrations that enter it.

The construction and operation of a golf course may have significant impacts on water quality. Contamination of surface water may result from frequent or over-application. Research has shown that up to 1.85% of applied glyphosate (e.g. Roundup) can be transported through runoff (4).

Surface water is used for many different purposes including wildlife habitat, municipal water supplies, and recreation. Therefore, maintaining surface water quality in streams is an important concern. To maintain good surface water quality, best management practices are required for every stakeholder to minimize the pollutant loading to streams. The goal of this research was to determine pesticide runoff from golf course-dominated watershed and to determine the effectiveness of detention ponds to manage pesticide runoff from an operating golf course.

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Materials and Methods

This research was conducted on Colbert Hills Golf Course in Manhattan, Kansas (Figure 1). This was an excellent site to study nutrient and pesticide fate on a watershed scale. The water-

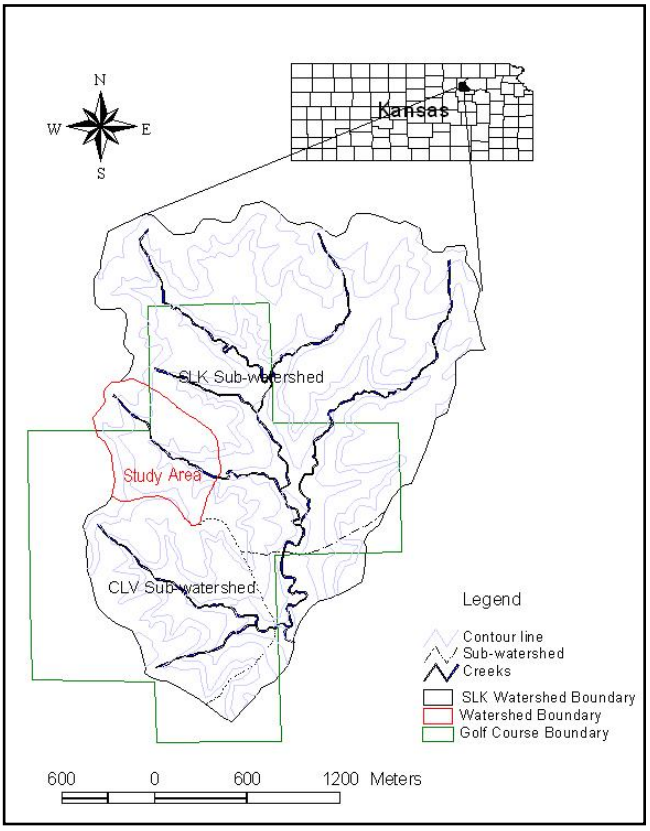

Figure 1. The study area was located at Colbert Hills Golf Course located in the Flint Hills region of northeastern Kansas near Manhattan.

Material	Aquatic Invertebrates (48-hr EC_{50})	Algal Species (72-hr EC_{50})	Coldwater Fish (96-hr LC_{50})	Warmwater Fish (96-hr LC_{50})
Roundup	1,634	15	322	491
AMPA			>1,000	

Table 1. Toxicity information for Roundup and AMPA on different aquatic species. Limits are listed in mg/L or ppm.

shed for the 1.2 ha (3 acres) detention and irrigation pond on this site is 46 ha (115 acres) shown in Figures 2-5. Two golf course holes (9 and 18) border the pond on either side. The previous golf course condition was primarily undisturbed prairie. The watershed is now turfgrass.

To determine the transport of pesticides, water and soil samples were taken from the study area. Water samples were taken at sites where water enters and exits the detention pond. Samples were also taken from the pond itself allowing for the pesticide transport process to be determined.

According to the Material Safety Data Sheets (MSDS) for Roundup Weed & Grass Killer (glyphosate) and Rotam Rophosate (AMPA), the products are mostly non-toxic to non-target organisms. Plants metabolize the Roundup to AMPA which is a major plant metabolite. Toxicity information was listed in the MSDS for various aquatic species (Table 1). EC_{50} is defined as the "*Effective concentration* (EC): Concentration of a substance that causes a defined magnitude of response in a given system: EC_{50} is the median concentration that causes 50% of maximal response." LC_{50} is defined as the "*lethal concentration*: Concentration of a potentially toxic substance in an environmental medium that causes death of 50% of the organism population following a certain period of exposure". These levels should not be reached in order to maintain the current ecosystem in the watershed.

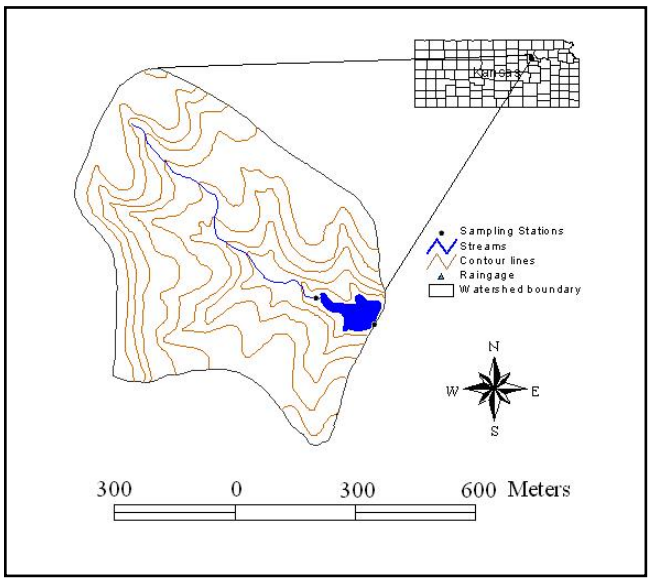

Figure 2. The watershed for the detention and irrigation pond covered 110 acreas at Colbert Hills.

Figure 3. The detention pond was studied to see how much of the applied pesticide ran off into that water resource.

Figure 4. Before the golf course was built, the rolling tallgrass prairie was used for grazing cattle.

Figure 6. To take samples from fairway drains, a glass bottle was developed and used that automatically seals when the bottle is full.

Water samples were taken by ISCO automated water samplers at the inlet and the outlet of the detention pond. Samples were only taken during runoff producing rainfall events in order to collect samples most likely to contain pesticides. The depth of the flow was measured at each of these sites. Water samples were also taken from three separate fairway drains. To take samples from the drain, a glass bottle (Figure 6) was developed and used that automatically seals when the bottle is full. The drains are connected and eventually drain into the pond (Figure 7). This allowed for samples from both rainfall events and irrigation. Samples of the pond water were taken every month. There were seven locations in the pond where samples were taken at three different depths (25%, 50%, and 75% of the total depth of the water in detention pond).

Soil samples were taken around each fairway drain to determine the partitioning of pesticides between soil and water. Soil samples were taken in a radial pattern in six directions around each drain with a manual core sampler (Figure 8). The samples were taken at 1, 2, and 5 meters from the drain. There were a total of 18 soil samples taken from each drain once per year (Figures 9-

Figure 5. Water samples were taken at sites where water enters and exits the detention pond. Samples were also taken from the pond itself allowing for the pesticide transport process to be determined.

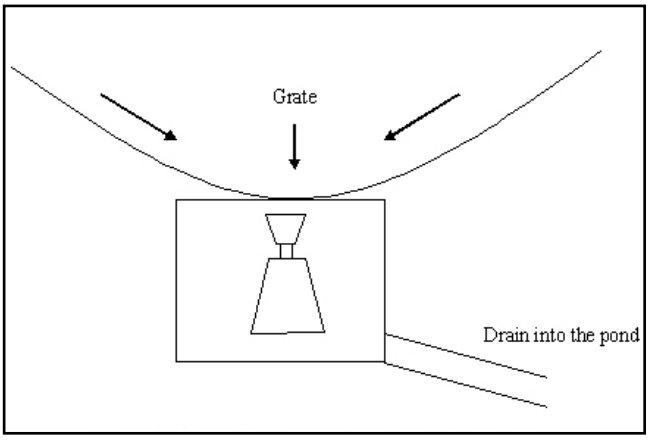

Figure 7. The specially designed glass bottles were placed into the fairway drains that eventually drained into the detention pond.

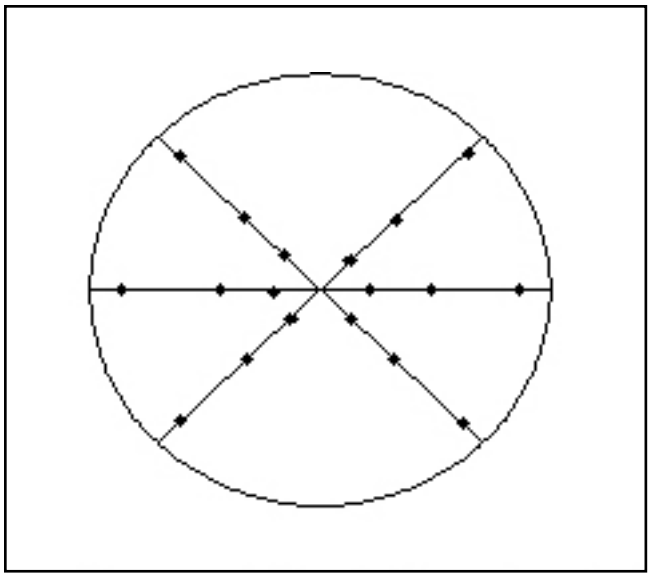

Figure 8. Soil samples were taken in a radial pattern in six directions around each drain with a manual core sampler.

Figure 10. By manually sampling soil around the drainage grates, pesticide movement could be quantified.

11). Sediment samples from the bottom of the pond were also taken on an annual basis.

At the start of this project it was planned that Ronstar (oxadiazon), Dimension (dithiopir), and Momentum (pendamethalin) would be applied to the course sometime during the study period. Since this study was focused around a functioning golf course, the course superintendent determined that these pesticides were not needed during the study period. Roundup was the primary pesticide applied to the watershed to control cool-season plants in the zosiagrass fairways. Roundup adsorbs to soil very quickly after application, so it was expected that there should be very little pesticide detected in the the surface water.

Results and Discussion

To date, nine water samples most likely to contain glyphosate have been tested. The testing

Figure 9. A total of 18 soil samples were taken from each drain once per year

Figure 11. All of the tests conducted thus far have shown levels of glyphosate much lower than the limits listed in the glyphosate MSDS, although additional analyses will be done.

Date of Sample	Glyphosate	AMPA	Glufosinate
10/18/01	<0.10	<0.10	<0.10
10/18/01	<0.10	<0.10	<0.10
10/18/01	<0.10	<0.10	<0.10
5/7/02	5.18	22.00	<0.10
5/21/03	3.25	6.11	<0.10
7/2/03	0.63	0.80	<0.10
7/23/03	<0.10	0.64	<0.10

Table 2. Pesticide results of Colbert Hills Golf Course (Manhattan, Kansas) fairway drain water samples in micrograms per liter (ppb).

was done the United States Geological Survey (USGS) Lab in Lawrence, Kansas. Glyphosate was extracted and analyzed. The detection limit for the test was 0.01 g/L. This is a very intensive testing procedure. The lab analysis was determined to be very difficult to perform in-house. Seven water samples from the fairway drains and two samples from the pond have been tested. These samples were chosen because they were taken shortly after Roundup was applied to the golf course.

The test determined the concentration of glyphosate (Roundup), aminomethylphosphonic acid (AMPA), which is a degradation product of glyphosate, and glufosinate, which is a product similar to Roundup (Table 2 and 3). Fourteen more samples that are most likely to contain glyphosate are currently in the process of being tested by the USGS Lab. Samples to be tested were from early runoff events generally during April and May of 2002 and 2003.

All of the tests conducted thus far have shown levels of glyphosate much lower than the limits listed in the glyphosate MSDS (Table 1). The highest reading has been 22 ppb for AMPA. This is also below the risk levels from the MSDS for AMPA. There have not been any pesticides detected in any of the tested pond samples. The detention pond has done an excellent job in diluting and breaking down the pesticide concentrations that enter it.

After completion of this project it is expected that we will better understand the pesticide and management practice for the golf course. We will have a better understanding of pesticide partitioning among soil, water, and biomass elements. We also hope that this study will lead to an understanding of the degree to which detention ponds can affect the fate of pesticide movement and the surface water quality.

Acknowledgement

The authors wish to thank USGA's Turfgrass and Environmental Research Program for its support of this project.

Date of Sample	Depth of Sample	Glyphosate	AMPA	Glufosinate
8/6/03	6 feet	<0.10	<0.10	<0.10
8/6/03	8 feet	<0.10	<0.10	<0.10

Table 3. Pesticide results of Colbert Hills Golf Course pond samples in micrograms per liter (ppb).

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