Are We Guilty?

Is Water Pollution Happening at the Golf Course, Or - Do Our BMPs Really Work?

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Good scientific writing usually demands that the third person be used. So, as a scientist, I rarely get a chance to use the first person. However, this seems to be one of those times when it is more appropriate. Over the last 10 years, I have been involved in more than 50 golf course projects from New York to California to Arizona to Florida to North and South Carolina involving water quality issues.

The theme, whether it comes from concerned citizens, environmental watchdog groups, or regulatory agencies at the federal, state, or local level always is the same - how are you going to stop all the pollution coming from the golf course? Whenever these questions arise, I first become a little defensive.

Often my response is - why do you believe that there are water quality problems associated with golf courses? The reply is always the same - but, they douse the golf course with all those toxic pesticides and fertilizers and other chemicals and they are constantly out there spraying!

Now, there are several issues here:

First, are pesticides toxic? Of course they are - if they were not they would not be labeled as pesticides. Government regulations require that materials which are applied for the use of controlling plants or animals be regulated because they injure or kill specific organisms. The general public, whose level of scientific understanding may be limited or simply non-existent, just doesn't seem to be able to differentiate between how a material can control say an insect, and not be a health concern to them.

A prime example is use of the materials fipronil (Chipco Choice for mole cricket control) and imidacloprid (Merit for grub control). These materials are also sold for flea and tick control (Frontline and Advantage respectively) in the little plastic tubes you apply directly to your pet and it provides extended control of these serious pest problems. Fido and Fluffy don't go belly up with a direct application, yet, the public is fearful of exposure with an application to turf where there is no direct contact with the concentrated form.

The second issue is - why does someone assume that just because we spray pesticides or apply fertilizers they end up in the water? Or, even if small quantities of materials do end up in the water, why do people assume it creates an environmental problem?

Part of the answer to this question is that the questioner obviously may have a poor understanding of biology, chemistry and ecology. However, even those people who are more scientifically oriented erroneously make unfair assumptions. Here is an example - golf courses spray pesticides; there are ponds, lakes and streams on golf courses; the pesticides must be getting into the ponds, lakes and streams. Simple logic seems to follow here. Or, what about the fertilizers you apply - all that nitrogen is probably polluting the Neuse River because they have nitrogen problems in the Neuse and there are golf courses in the river basin.

Yet, what has been ignored are basic questions that everyone should ask:

- What do we know about what happens to the materials applied to golf courses?
- Have any scientific studies been conducted which have documented the fate of nutrients and pesticides applied to golf courses?
- What about golf courses that are monitoring the quality of surface water and groundwater? What are they finding in their sampling?

The Press - Often Another Problem!

Over the last 15 years, water quality issues on golf courses have been a hot topic in the press. Often assertions are made that if a new golf course is being considered for construction, it will contaminate the streams and lakes and everyone's drinking-water wells in the vicinity. Even on existing courses which have operated for years, the press often insists that water quality, and, in some cases, quantity are seriously jeopardized by the golf course at the center of their focus.

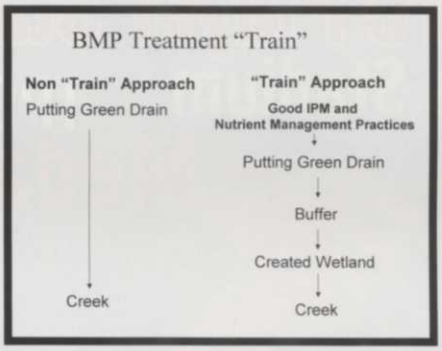

Figure 1. A Generalized Concept of the Best Management Practices "Train" Approach to Managing Resources.

Probably the most notorious example was the article in the *Wall Street Journal* which headlined, "Golf Courses Are Denounced As Health Hazards" and featured a cartoon of golfers dressed in protective gear while playing the course. The focus of the article was that golf courses, in the reporter's opinion, used too many chemicals which are of course toxic. (By the way, what is "too many" and how would he know?)

Once, when such an article on water quality concerning the Neuse River appeared in the Raleigh *News and Observer*, it stated that "City sewage, industrial wastewater, farm fertilizers, livestock manure and lawn and golf course chemicals are changing the Neuse (River), choking it with nitrogen and phosphorus." I called the reporter and told her that I had worked with the Division of Water Quality on water quality issues and was somewhat up to date on the concerns. I asked her where she got her information, where the studies had been conducted which had determined that golf courses were causing water quality problems because I had kept up with the literature fairly closely and I wanted to obtain a copy. The reply I received was typical

"Well, I don't know that there have been any studies, I was just making a generalization!"

Wow, what a generalization. Let's see if I understand it correctly - golf courses apply fertilizers so the nutrients must be ending up in the Neuse River. How about I make a generalization - people die in automobile accidents, so your car must have killed someone! Is that close?

I became a little agitated in my discussion with her and ultimately she cut me off with - "I'm sorry you are so upset, maybe you could write a letter to the editor." Well, she entirely missed my point. Responsible journalism demands that you investigate the facts, not form generalities. However, more and more we see in the press stories which are one-sided. Why? Because they are easier to write! Why ruin a good story with facts?

The Beginning

Interest in the environmental impact of golf courses on water quality is not new. For the past 30 years, various research studies have looked at the movement of specific chemicals under differing golf course conditions, especially on sand-based root-zone-mix putting greens and for nitrogen-source losses under a variety soil conditions. All of these studies were efforts to first document what was actually happening and then second to develop Best Management Practices to eliminate or minimize problems. With the onset in the early 1980s of scientists and regulators more intensively studying pesticides and nitrates in groundwater because of health concerns, it was inevitable that golf courses would ultimately come under scrutiny.

Now, I'm not opposed to that. In fact, I believe that all golf courses should be monitoring water quality at their sites for several reasons:

First - it documents what the facts are; this gives a sound basis to refute claims which may arise as to how your management is affecting the environment.

Second - it documents how effectively the BMPs are working, regardless of whether they are the Land Use (those physical factors which are put in place through good course design and engineering such as retention/detention ponds, vegetative filter strips, buffers, etc.) or Source Prevention - how good a job you are doing in your management, what I like to call Intelligent Management. Of course, this assumes that first, you care about how good a job you are doing (let's make this a basic assumption) and that second, you understand what you are trying to accomplish as to not overloading the ecosystem's capacity to function (this is the subject of another article at a later time.)

The Facts

While there are numerous scientific studies which have been conducted at universities around the US and beyond to look at pesticide and nitrogen fate, many are often are criticized because they are not conducted at golf facilities where day-to-day conditions dictate the management practices the superintendent faces to keep the course playable.

While these "academic" type of studies are critical to developing an understanding of the many complex factors which affect how pesticides and nitrogen behave, the ultimate concern is what are the water quality conditions at actual golf course facilities. The following summarizes the major studies which have been published, either in peer reviewed scientific journals or under scientifically rigorous conditions specifically for environmental regulatory or health agencies.

Massachusetts

One of the first studies which documented water-quality conditions on golf courses was published in 1990 in the journal *Ground Water Monitoring Research* (Cohen et al., 1990). This study was undertaken under the auspices of the Environmental Protection Agency.

Groundwater quality was monitored at 19 wells on four golf courses on Cape Cod in Massachusetts. This location was chosen because of fragile ecological conditions - sandy soil profile, high rainfall totals, shallow groundwater. The golf courses chosen were all more than 30 years old so they had a long history of fertilizer and pesticide use. Sampling sites were clustered around areas where the highest amounts of materials were used, greens and tees, and then under the fairways.

Summary of findings:

The wells were monitored for 17 pesticides. Of these, seven of the 17 chemicals were never detected in water samples. Of the 10 materials which were detected, only chlordane (which is no longer used on golf courses) exceeded Health Guidance Levels (HGL).

Of the 12 materials which were legally registered for use at the time the study was conducted, none were found in concentrations greater than one-fifth of the HGL. Nitrate-N concentrations were generally below the 10 ppm federal (and World Health Organization) Maximum Contaminant Level (MCL). Based on the spatial and temporal data collected, nitrate-N concentrations decreased in response to lower application rates and use of slow-release fertilizer formulations.

This pioneering study answered a lot of questions. It also opened up a lot of discussion based on the authors' conclusions that: "this was one study with one set of pesticides in one hydrogeological setting." This was what drove the initiative to start more closely documenting both surface water and groundwater conditions at other golf course locations.

What was highly significant in this study was the observation that "turf management practices are closely related to nitrate concentrations in groundwater. Rate and frequency of fertilizer application as well as type of fertilizer used appeared to be significant factors in ground water nitrate-nitrogen concentrations beneath managed areas". While everyone in turf management has preached this for years and intuitively it certainly makes sense, having scientific proof lends much more credibility to what can be accomplished.

Florida

In 1996, the US Geological Survey released a report which was prepared in cooperation with the Florida Department of Environmental Protection and Hillsborough County in Florida (Swancar, 1996). This report was based on a four-and-a-half-year study of pesticide occurrence in groundwater, surface water and irrigation water on golf courses in Florida.

This study was much more exhaustive in scope than the Cape Cod Study. Three pairs of golf courses were selected to determine the effect of irrigation with reclaimed water on pesticide leaching. Each pair consisted of one golf course using ground water for irrigation and one using reclaimed water.

Pairs were located in the same area and had similar pesticide use. Three additional golf courses were added in the second year of the study to obtain data on pesticides in other areas of the state. On these nine golf courses, water samples from a total of 39 shallow wells, three irrigation systems, six golf course ponds, two reclaimed water-storage ponds and three wastewater-treatments plants were analyzed.

This study found that pesticides were detected in ground water samples on seven of the nine golf courses. However, 45 percent of all occurrences were at barely detectable (trace) levels and 92 percent of the occurrences were under the MCL or HGL.

Surface water samples showed similar results with 60 percent of the occurrences at trace levels and 95 percent of the occurrences were below the MCL or HGL. In fact, only three surface water samples out of 61 samples which had detections of materials had levels above the MCL, and all three were on the same golf course pond. Samples taken directly from deeper irrigation wells on two golf courses contained no pesticides above detection limits.

Criticisms of water-quality data comparisons often come from ecologists. They assert that water-quality samples are only compared with human health comparisons, and not with ecological standards.

Based on the pesticide detections found in this study, two of my colleagues: Dr. Miles M. (Bud) Smart, director of environmental planning for Audubon International, and Dr. William Warren-Hicks, an environmental toxicologist with the Cadmus Group in Durham, N.C., and I evaluated water-quality sample data using an aquatic community ecological risk model. What we found was most interesting. When we looked at the range of pesticide concentrations in surface water and compared it to the concentration of that pesticide which would put 5 percent of the genera of aquatic organisms at risk, none of the pesticide detections were even close (Table 1). The one of most concern, chlorpyrifos (Dursban) was still nine times lower in concentration than would put the ecological integrity of the aquatic system at risk. Thus, even though detections are occasionally noted, their environmental impact is rare.

New Jersey

A study was conducted in 1999 at Ocean County Golf Course at Atlantis in Little Egg Harbor (Meyer, 2000). Samples were obtained from surface water in and around the Atlantis Golf Course on a weekly basis from April through October. Students from Georgian Court College in Lakewood, N.J. collected the samples and the Pesticide Residue Laboratory of the Pesticide Control Program at the New Jersey Department of Environmental Protection analyzed all of the water samples.

The results from this study point out quite a few interesting facts:

First - the majority of the pesticide residues detected were not associated with the routine insect and disease control measures employed on the golf course - they were residues from previous use of DDT for control of soil-dwelling insects which moved into the ponds bound to particulate matter and malathion used by the county for mosquito control.

Second - when the New Jersey scientists made a comparison of the levels detected with environmental levels of concern *(Table 2)* just like in the Forida study, the maximum levels detected compared to the lowest aquatic reference level there was no risk to the aquatic ecosystem in the ponds sampled.

New York

Long Island has for many years now been concerned with its groundwater because it is a source of drinking water for so many people and the island has a long history of farming and pesticide use. In October, 1997 the Suffolk County Department of Health Services teamed with the New York State Department of Environmental Conservation to conduct a comprehensive examination of pesticide impacts on groundwater. Like the Florida study, this was much more extensive than the Cape Cod project. This project was not limited to golf courses, but they were included. Groundwater impacts resulting from pesticide and fertilizer use were examined by testing 31 wells located at 18 Long Island golf courses.

Only the dacthal metabolite TCPA was found above the MCL in the golf course monitoring, in one well in each county. Dacthal is no longer used in NY, one of the reasons being it was applied at a very high rate and was known to be very persistent in the environment unlike the currently labeled chemicals. As for fertilizer concerns, nitrate concentrations for the wells averaged 4.3 ppm and the median nitrate concentration was 2.6 ppm, well below the health standard for drinking water of 10 ppm. The authors of the study concluded:

"The monitoring results indicate that turf management practices can effectively control impacts to groundwater at golf courses."

While this is not surprising to those of us in the turf business, it is something we like to hear someone else conclude!

The Nation

In 1999, an article entitled "Water Quality Impacts by Golf Courses" appeared in the *Journal of Environmental Quality* (Cohen, 1999). The authors examined water quality data from seventeen studies (on 36 golf courses). A total of 16,587 data points from pesticide, pesticide metabolite, pesticide solvent and nitrate analyses of surface water and groundwater were reviewed. What they found was remarkable:

Table 1

Pesticide	Concentration to affect 5% of aquatic genera(ppb)	Concentrations Found in Florida study(ppb)
acephate (Orthene)	1,352	1.5 to 20.1
bensulide (Betasan)	377	not detected
chlorothalonil (Daconil)	5	not detected
chlorpyrifos (Dursban)	0.9	0.1
simazine	2,730	0.08 to 38

- None of the authors of the individual studies concluded that toxicologically significant impacts were observed, although Health Advisory Levels (HALs), Maximum Contaminant Levels (MCLs) or Maximum Allowable Concentrations (MACs) were occasionally exceeded.
- The individual pesticide database entries that exceeded HALs/MCLs for groundwater were 0.07% of the total.
- The individual pesticide database entries that exceeded HALs/MCLs for surface water were 0.29% of the total.
- The MCL for nitrates in surface water was never exceeded.
- The MCL for nitrates in groundwater was exceeded in 3.6% of the samples; however most of the samples where the nitrate MCL was exceeded were apparently due to prior agricultural land use.

They concluded, as did the New York and New Jersey investigators, that "widespread and/or repeated water quality impacts by golf courses are not happening at the sites studied."

North Carolina

In 1994, a graduate student at North Carolina State University evaluated surface water quality at three golf courses in coastal North Carolina (Ryals, et al., 1998). He sampled surface water at these sites every two weeks from January to December. Each course has a sandy loam soil and adjoining wetlands, saline marshes, or elevated water tables. They concluded from this study: "The data indicate that impact to the surface waters from the courses was minimal. Of the four pesticides (atrazine, chlorothalonil, chlorpyrifos and 2, 4-D) and two nutrients (nitrogen and phosphorus) surveyed, only 16 samples exceeded the US EPA HALs. (And these were from locations on the golf course). All analyses of the samples collected from the outflows of the courses were below their detectable limits."

Now, sixteen may sound like a large number of samples which exceeded a threshold which is considered a problem, except they evaluated 1,578 samples so excessive samples represent around 1% of the samples. Furthermore, these were all nutrient problems, not pesticides, something which can be easily controlled with changing the BMPs used at the course.

Additionally, all of the detectable pesticide levels were below environmental hazard levels (based on the LC50 value), and none of the samples collected from the natural areas surrounding the three courses or from the outflows from the courses showed detectable pesticide residue levels.

The Center for Marine Science at the University of North Carolina at Wilmington has also been investigating water quality as impacted by five golf courses in coastal North Carolina (Mallin and Wheeler, 2000). These studies occurred over a period from 1993 to 1998. The authors of this study drew some conclusions based on their interpretation of the data:

- "In general, nitrate levels were greater in streams leaving the courses compared with streams entering the courses, but concentrations varied considerably"

My comments on the interpretation of their data:

Outflow site nitrate+nitrite concentration averaged over 1993-1997 from the five golf courses was 0.055, 0.107, 0.315, 0.321, and 1.462 ppm. Now,

Comparison of Detections of Pesticides Currently in Use with Environmental Levels of Concern

Pesticide	Maximum Level Detected (ppb)	Environmental Level (ppm)	Ratio (1/1 would pose a risk)
Chlorothalonil	0.46 _g/l	250 _g/l/96 hr LC50 - rainbow trout	1/543
dichlorvos	0.34 _g/l	900 _g/l/96 hr LC50 - bluegill	1/2647
malathion	1.02 _g/l	64 _g/l/96 hr LC50 - walleye	1/63
metalaxyl	0.6 _g/l	>100,000 _g/l/96 hr LC50 - rainbow trout, carp, bluegill	1/166,667
methoxychlor	0.37 _g/l	17 _g/l/96 hr LC50 - Atlantic salmon	1/46
metolachlor	0.005	2000 _g/l/96 hr LC50 - rainbow trout	1/400,000

ecologists suggest that eutrophication does not occur until surface water has total N concentrations is greater than 0.75 ppm and moderately enriched water only when it is greater than 1.25 ppm. Thus, only one golf course has a moderately enriched nitrogen condition from nitrates and none of them came close to the health level of 10 ppm. The authors of this study point out that there are some recent studies that indicate that in controlled conditions, nitrate levels this low have caused serious phytoplankton bloom formation in Neuse River estuary waters and that these levels may be associated with declines of seagrass thereby creating problems with coastal fish habitat. However, they sampled directly at the golf course, not in areas where dilution would appreciably lower the nitrate concentrations.

Other conclusions they drew:

• "Orthophosphate concentrations were elevated on mid-course sites on two courses (out of five), but were low in the outflow water except at one course."

• "The golf courses studied were not significant sources of fecal coliform bacteria to nearby waterways; in fact, passage through some courses served to reduce coliform loads entering from upstream suburbs."

My comment on their conclusion:

Imagine that, water entering the golf course from an urbanized area is actually *filtered* by the land-use practices on the golf course!

• "Landscape management practices appeared to play a critical role in determining nutrient concentrations in the outfall and at mid-course sites."

My comment on their conclusion:

Does this sound like intelligent management plays a role, such as using good BMPs?

Here is their overall conclusion:

"Vegetated buffer zones, wet detention ponds, and wooded wetland areas led to considerably lower nutrient output than sites lacking such management practices and should be used whenever possible to protect nutrient-sensitive receiving waters."

In 1992, the US Golf Association published a book entitled "Golf Course Construction and Management - Environmental Issues" edited by James C. Balogh and William J. Walker. In this book, they pointed out that BMPs are used in an attempt to reduce the adverse water quality and environmental effects of agricultural and forestry management systems. They included a number of goals of BMPs including the following:

• to reduce the offsite transport of sediment, nutrients and pesticides

• to control the rate, method and type of chemical being applied

• to reduce the total chemical loads by use of IPM, economic thresholds, alternate pest control options and fertility testing

• to use both biological and mechanical soil and water conservation practices

About this time, Livingston and McCarron (1991) started promoting what they termed the idea that a stormwater management system might be considered as a "Best Management Practices (BMPs) Train" in which the individual BMPs are considered the cars *(Figure 1)*. This concept promoted that water taken through a combination of treatment processes such as vegetated filter strips, retention ponds, created wetlands, etc. which would each reduce the pollutant load in each treatment process ("car in a train") by some percentage. Therefore, prior to discharge into the natural environment pollutant concentrations would be so low there would be no impact and that the natural biogeo-chemical cycling of the ecosystem would not be disturbed. As part of this, an intelligently managed golf course management program which starts with good design and engineering and then incorporates a good IPM program into the BMPs Train concept could be protective of water quality.

Thus the UNC-Wilmington data strongly support this whole concept!!

The Message

Best Management Practices do work! Is there really any need to expound on this further? However, as long as you and I are in the turf industry, we will continue to be the target of special-interest groups and an uninformed (and many times unwilling to be informed) press as well as individuals. You have a choice - continue to manage the way you have been and ignore the opportunity to prove how effective your management really is - or, review and revise your management practices to attain the BMP goals Balogh and Walker mention. Monitor your surface water and groundwater so you can look anyone in the eye and tell them that your golf course doesn't have any water-quality problems, you have the data to prove it, and you are backed by numerous scientific studies which have been conducted over the past 18 years, and you will be happy to provide them the scientific literature citations!

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