End of the Line for Nutrients and Pesticides

USDA scientists investigate a novel approach to protect water quality surrounding golf courses.

BY KEVIN W. KING, SHEELA G. AGRAWAL, JAMES F. MOORE, AND JIM BALOGH

It is often necessary to install subsurface drain lines to reduce soil moisture levels for healthy plant growth. Properly installed drain lines retain sufficient amounts of water and air in the soil, as well as stimulate microbial activity. Drain lines help prevent rutting and soil compaction by golf carts or maintenance equipment, and they allow golf course access soon after heavy rains. However, subsurface drainage may carry nutrients and pesticides to surface waters. In this way, subsurface drainage bypasses managed and natural filter processes, including riparian zones and vegetated buffer strips.

Various filter materials are being tested for their efficacy to remove nutrients (N and P) and pesticides (chlorothalonil, mefenoxam, and propiconazole) from drain lines before leachate is discharged into surrounding surface water.

The goals of this research were to investigate the use of industrial by-products and natural minerals as filter media to reduce the amount phosphorus and three pesticides (chlorothalonil, mefenoxam, and propiconazole) from golf course tile drainage outlets to surface waters. The most recent field study was conducted at the Ridgewood Country Club in Waco, Texas, using a filter housing designed by KriStar Enterprises, Inc. A different filter design will be assessed in the near future at the Royal American Golf Course located in Galena, Ohio.

The Texas experiment was conducted on an 8,000 square-foot, split-design chipping green. The green was originally designed to test alternative materials for the gravel layer used in green construction. In lieu of gravel, the north half of the green was constructed with AirDrain Geocells (polypropylene plastic grid system covered by a geotextile), while the south half used a geogrid (double-layer, polypropylene plastic grid sandwiched between two geotextile layers).

For this study, two filter boxes (which house three filter cartridges filled with by-products and natural minerals) were installed. Two storm events, which consisted of three 3,785-liter (1,000-gallon), 10-minute irrigations at 2-hour intervals, were simulated on separate days. Each day, phosphorus, mefenoxam, chlorothalonil, and propiconazole were applied to the green prior to the first irrigation and according to the manufacturer's specifications.

On day one of experimentation, no filter media were placed into the cartridges to determine the influence of the filter box construction itself on contaminant removal. On day two, the empty cartridges were swapped out for new ones filled with a 14-liter blend of blast furnace slag, cement kiln dust, zeolite, sand, and coconut-shell activated carbon.

A total of four Isco 6712 portable samplers were positioned to collect simultaneous water samples at the inflow and outflow of the filter boxes, thus providing a before-and-after assessment. Flow measurements were recorded by two Isco 4230 bubbler flow meters located at the discharge end of the filter boxes and ranged from 0.0034 L/s (0.05 gal/min) to 0.6433 L/s (10.16 gal/min).

Water samples and flow measurements were collected and recorded at predetermined time intervals throughout the course of the storm simulations. Pre- and post-filter phosphorus, chlorothalonil, mefenoxam, and propiconazole loads were calculated by multiplying sample concentration measurements by flow rates. Of the four contaminants investigated, only chlorothalonil was removed in statistically significant quantities.

Median chlorothalonil removal was 69%, while the highest was 96%. Interestingly, chlorothalonil removal was very high at peak flows. Phosphate, mefenoxam, and propiconazole were not removed, highlighting the need to optimize the filter blend as well as the importance of conducting field-scale versus laboratory-scale studies. In a previous laboratory-scale study, these by-products and minerals removed >85% quantities of the investigated contaminants, which was not the case in the field.

Our studies indicate that the most important factor in developing an end-of-tile filter is designing the system to handle larger flow rates, which directly impacts the amount of contact time with the filter materials. In general, the longer the contact time, the greater the removal efficiency.

precipitation. For phosphorus, we have experimented with granulated blast furnace slag and cement kiln dust. For pesticides, we are using activated carbon, a material frequently used in water treatment facilities. In addition to their

Dr. Kevin King checks the status of the end-of -tile filters installed on a chipping green at the Ridgewood Country Club in Waco, Texas.

CONNECTING THE DOTS

An interview with DR. KEVIN KING *regarding the research of end-of-line filters for removing nutrients and pesticides.*

Q. *Do your results to date suggest that end-of-tile filters can be effective at removing nutrients and pesticides from golf course leachate?*

A. Depending on the chemistries of the pollutants and the hydrologic characteristics, filters could be successfully used on golf course drainage lines. The products that we are currently investigating have a strong affinity for phosphorus and some pesticides.

Q. *What kinds of materials are used to filter water, and what kinds of characteristics are important for them to be effective at removing nutrients and pesticides?*

A. Phosphorus seems to be the primary nutrient of concern in golf course discharge waters; thus, we have focused on materials high in iron, aluminum, and calcium. The materials should also have a large surface area that increases the number of exchange sites, leading to more adsorption and surface area and adsorptive capacity, the materials must be permeable enough to permit water to flow through them.

Q. *Are the materials similar to those used in tap water filters that homeowners can attach to their kitchen faucets?*

A. Yes and no. The materials used for home filtration systems are primarily composed of sands and activated carbons, similar to what we are using. More recently, home filtration systems are using membrane technology.

Q. *Besides the chemical characteristics of the filter material, what design elements are crucial in developing a system to remove nutrients and pesticides from golf course leachate? How important are factors such as flow rate and the time leachate resides in the filter?*

A. Our studies indicate that the most important factor in developing an end-of-tile filter is designing the system to handle larger flow rates that directly impact the amount of contact time with the filter materials. In general, the longer the contact time, the greater the removal efficiency.

Q. *Do some other facets of agronomy (i.e. row-crop agriculture) currently use end-of-tile filters for similar purposes? If so, how successful have they been?*

A. There is a significant effort underway to develop both end-of-tile and in-stream treatment technologies for the agricultur industry. Those efforts are being met with the same challenges, primarily flow rate. Treating 100% of the discharge waters is not a feasible undertaking, so the general consensus is that we need to treat the lower flows. For example, the lower 50% to 60% of flows are treated, while the remainder of flow is bypassed and untreated.

Q. *If proven successful, how long would you estimate that end-of-tile filters could be useful? In other words, how often would superintendents have to change filters (or filter material) from end-of-tile units from a golf course putting green or section of fairway?*

A. The life expectancy of the filters is really tied to the type and amount of pollutants and the amount of filter material that is used; the more filter material, the longer the life expectancy. This really gets back to the design. Our experience thus far suggests that the cartridge-type system that we are researching has a life expectancy of approximately six months to a year. We believe that for the golf industry a filter can be designed that would last at least a year, and maybe two.

Q. *When "charged" or used filter materials are ready for replacement with fresh filter media, how do you see the "charged" material being handled? Since filter materials would contain pesticides and nutrients, would they need to be handled as hazardous materials, or could "charged" filter materials be topdressed on turfgrass sites and let the natural degradation process take place?*

A. We do not have a clear answer for this question. However, we do not believe that the spent materials would be considered hazardous, and they would be permitted to be surface-applied back to the golf course. Further investigation is required to fully answer this question.

Q. *Do you feel that public concern about water quality could someday lead to regulation that mandates the use of end-of-tile filters for golf courses? Is the USEPA aware of your work, and, if so, what has their response been?*

A. I am not aware of any formalized public concern over water quality. The concern appears to me to be agency driven. My personal opinion is that we are already at the regulation point. For any new development or existing course redevelopment, receiving a permit for a sensitive area requires a mitigation strategy. Everything that the golf industry can do to head off further regulation is a good thing. To my knowledge, the USEPA is not aware of our research. Historically, tile outlets have not been considered point sources, and we do not want our research to lead to that debate.

Q. *Have you implemented end-of-tile filters on watershed-scale sites? If so, have these sites included golf courses and how effective have they been to reduce nutrient and pesticide concentrations of watershed leachate?*

A. We are just now initiating some watershed-scale filtration research using the end-of-tile concept, so we don't have any preliminary results to discuss at this time. The site where we are conducting our research is a 3,400-acre watershed in central Ohio. The land use in the watershed is primarily agriculture. The outlet of the watershed is a spillway of an approximately two-acre pond located on a golf course. The pond is the primary irrigation supply for the golf course. We have installed a flow-regulating structure at the outlet of the pond and have started to investigate different filter materials and designs for capturing both nutrients and pesticides.

Q. *What impact do you see the results of your work having on golf course management in the future?*

A. Once an efficient design has been developed and tested, we anticipate the implementation of the system for sensitive areas only or for courses needing to meet compliance standards. As far as the impact on management, we hope to keep that at a minimum. As previously stated, the idea is to develop a low-maintenance system.

If end-of-tile filters are proven successful, questions still remain. For example, how often will filters need to be replaced, and how will the used filter materials be handled?

Public concern for protecting surface water quality was the driving force for this research. The results may have potential to significantly affect future golf course design and management.

JEFF NUS, Ph.D., *manager, Green Section Research.*

RESOURCES

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