What Are We Missing When We Sample Putting Green Soils?

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When we talk about taking soil samples, what are we really talking about? Typically, we mean pulling several plugs from the top 3-6" of the profile, mixing them together in a bag, and sending it off to a soil test laboratory. From this, we get a wealth of information that helps us guide the application of fertilizer and soil amendments. We focus on the top 3-6" of the profile because this is where most of the roots are and also where we find thatch and potential organic layers. We like to look at the profile and see how effective our topdressing has been over time. Almost every management practice that we employ is for the benefit of the top 3-6" of the soil. But if you have USGA-spec putting greens, sampling only the top 3-6" may not be enough.

The design of a USGA green allows the root zone to hold water evenly for long periods of time, while still draining quickly during rain events. This is accomplished by the layering of sand over a layer of pea gravel, which creates a pseudo perched water table. This design has been proven successful since its introduction about a half-century ago but it is not without problems.

In any soil profile with textural boundaries or discontinuities, it is common to see soil chemical changes, such as mottling or redoximorphic features (Fig. 1). In natural soils textural boundaries are typically subtle, but the boundary in USGA greens is very abrupt. When water is perched above the pea gravel layer, the chemistry of the soil and water becomes very important, and potential exists for mineral or organic layering to occur at this boundary.

Case Study

During a summer internship at a golf course in Hawaii, I encountered a unique soil-layering problem. We first noticed thinning turf, especially in low areas of the putting green where water drained. We found black layer in the surface 6", but this didn't make much sense: the course was only five years old, core aerification was done twice each year, and greens were topdressed weekly. We decided to dig deeper, thinking that maybe something was blocking water infiltration deeper in the profile.

At the sand/gravel interface of the first putting green we sampled, there was a thin layer of what looked like oxidized iron (i.e., rust) that was cementing sand and pea gravel together (Fig. 2). This layer was brittle, but impenetrable to water, which created anaerobic conditions in the root zone. As we continued investigating, we found this layer in every green we sampled.

Years later, I started graduate school at UW-Madison. The superintendent sent me some samples of this layer, and I confirmed that it was oxidized iron through physical and chemical analyses. I thought that this was a rare, unique problem when I first witnessed it in Hawaii. But now that I've studied it more and more, I have heard of or seen examples of this iron layer in Texas, Missouri, Virginia, Pennsylvania, West Virginia, California, North Carolina, and even Vietnam.

Figure 1. Redoximorphic features in a natural soil. Red color is oxidized iron (i.e., rust).

Figure 2. Iron oxide layer observed at the sand/gravel interface (12" depth) of a putting green.

Now I am on a mission to find out exactly what causes this layer to form, how to prevent it, and what to do if you already have it. My hypothesis is that the iron contained in irrigation water, or added through fertilization, is pushed downwards through the profile until it hits the pea gravel layer, where the water is perched. When soluble reduced iron is exposed to this oxygen-rich pea gravel layer over an extended period of time, the iron oxidizes and precipitates along the interface.

The point of this case study is to show that the lower half of the profile can have just as many interesting features as the surface 3-6", and these features can drastically impact the performance of the putting green. If we didn't sample the full profile in Hawaii, we never would have found the iron layer at the sand/gravel interface. Our conclusion would have been to increase aerification and topdressing frequency, and we would have been unaware of what was really causing the problem.

When we only sample the top half of the profile, we are only getting half of the picture. So why don't we sample the bottom half of the profile? Probably because it is inconvenient! Many t-probes aren't long enough to reach the pea gravel layer, and those that are long enough tend to be difficult to push down to that depth. The soil profile samplers that give you a cross-sectional view (Mascaro, Turf Tec, etc.) are an improvement over the t-probe, but even these don't usually sample the full profile down to the pea gravel layer.

Sampling Your Full Profile

For my graduate research, I am collecting full-profile samples of USGA-spec putting greens from at least 40 golf courses across the U.S., with the help of the USGA agronomists. From my experiences so far, I can share a simple and practical method that you can use to sample the full profile of sand-based putting greens.

The method that I will explain for full-profile sampling is very similar to Dr. Norm Hummel's method (http://www.turfdoctor.com/). All of the materials can be purchased at your local hardware/construction store, and the materials are relatively inexpensive, especially if you already have some of these things around your shop.

First, cut a 2" diameter PVC pipe (schedule 40) into segments that will be long enough to reach all the way down your pea gravel layer, plus four inches (typically 16-20"). About 2" from the top of the pipe, use a drill press to drill a hole that allows a 1 foot long piece of rebar to slide freely in and out through both sides of the pipe. Use a grinding wheel to sharpen the bottom end of the pipe, which will allow it to pass through the profile more easily.

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Use a rubber mallet to pound the PVC pipe into the turf and through the soil profile. Keep hammering, and eventually you will feel the pipe hit the pea gravel layer. Drive the PVC pipe down a few more inches to capture some of the pea gravel, making sure that the hole in the top of the pipe is still several inches above the ground surface. Insert the handle into the hole and slowly twist the PVC pipe, wiggling from side to side as you pull upwards. The soil sample should stay well intact inside the PVC pipe, but if it falls out the bottom, try hand watering the area to increase the soil moisture, and then try again.

Now that you have your full-profile sample out of the ground, it is time to crack it open. It is possible to use a circular saw, but I prefer to use a small, handheld oscillating saw ($40-100) as it offers more precise control. For safety you will want to build a small platform that will hold the pipe still while you saw it open. If you use a circular saw, the platform will need to be very sturdy, but if you use an oscillating saw, the platform can be as simple as a sheet of plywood with two boards running parallel to each other, spaced 2" apart. With the PVC pipe safely mounted, cut lengthwise on one side from top to bottom, being careful not to dull your saw blades by cutting into the soil. After one side has been entirely cut through, place a strip of duct tape over the cut to act as a hinge and prevent soil from falling out when you turn it over. After the duct tape is secure, flip the PVC pipe over and cut through the other side lengthwise from top to bottom. If your cuts are nice and clean, the pipe should open right up and your full profile will be fully visible.

Interpreting what you see in the soil profile is the hardest part of this entire process. Experts like Dr. Hummel have made careers out of analyzing soil profiles, and nothing beats experience. If you want an outside opinion, collaborate with your local USGA agronomist, or submit a sample to an experienced soil-testing lab that offers analysis of full profiles. Still, you probably know your greens better than anyone else. It is well worth your time and effort to take a full-profile sample and cut it open to look at it for yourself— you may find something that you didn't know was there (Fig. 2).

Full-profile sampling is not a substitute for sampling the top 3-6". This sampling is more cumbersome, and is not a convenient way to analyze chemical properties of the soil. However, collecting a full profile sample from troubled and healthy areas every 1-2 years would provide you with a better idea of how water, minerals, and organic matter are moving or accumulating in your profile. Take pictures each time you cut a core open—then you will have something to look at for comparison over time.

If you decide to take some full-profile samples and find any interesting layering occurring, we would love to take a look! Feel free to send a picture to me at obear@wisc.edu. The more information we share, the more we can learn about and describe unique soil-layering problems. Chances are, if you find layering in your putting greens, it is probably happening in somebody else's too!

Figure 3. Full putting green profile sample. Note the iron layering at 15" depth.

Sampling the Full Profile of Your Sand Putting Greens

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This method for full-profile sampling is similar to Dr. Norm Hummel's method (www.turfdoctor.com)

MATERIALS	**COST**
One section 2" ID PVC Pipe	$5.00
12" length rebar	$0.97
Rubber mallet	$5.00
Handheld oscillating saw	$40-100
TOTAL COST:	**$50-100**

Figure 1. 20" PVC pipe with sharp edge on bottom and hole drilled in top for handle

Figures 2 & 3. Cut the core open with an oscillating saw (left). Use duct tape over the first cut to create a hinge (right).

STEPS:

1. Cut 2" diameter PVC into a 20" long section.
2. Use a grinding stone to sharpen one end of the pipe. Drill a hole through the other end of the pipe, about 2" from the top. This is where the handle will go (Fig. 1).
3. Use a rubber mallet to pound the PVC pipe into the putting green. Keep pounding until you reach the pea gravel layer at the bottom of the root zone. Be sure to leave 1-2" of space below the hole at the top so that the handle can be easily inserted.
4. Insert the rebar handle into the hole at the top and twist the pipe around several times. Gently pull the sample upwards and out of the ground.
   ** If the sample will not stay intact as you pull it out of the ground, try hand watering the area for a few minutes to increase the soil moisture*
5. Use an oscillating saw to cut along the length of the pipe on one side. Place a strip of duct tape along the cut to act as a hinge (Figs. 2 and 3).
6. Flip the pipe over and cut the other side. The pipe should open up and your full profile will be on display (Fig. 4).

Figure 4. Full profile sample of sand putting green. Sand channels are from deep tine aerification.