//IRON OXIDE

Iron layering in two-tiered putting greens

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When was the last time you sampled the full profile of your sand-based putting greens? Many people rarely, if ever, sample the profile all the way down to the pea gravel layer. It's inconvenient, out of sight, and therefore out of mind. However, USGA-funded research from the University of Wisconsin-Madison suggests we might be missing the full picture when we fail to sample to the depth of the pea gravel.

Iron-oxide layering has been observed at the sand-gravel interface of two-tiered putting greens of many golf courses across the United States. This layer, which only forms in greens with a pea gravel layer, is detrimental to water infiltration and leads to anaerobic soil conditions and decline of turfgrass quality.

FIGURE 1

Black layer in the low area of a putting green, indicating poor drainage and anaerobic soil conditions. Sand-filled holes from recent aerification are visibly lighter.

PHOTOGRAPHY BY: GLEN OBEAR

FIRST OBSERVATIONS

In the summer of 2008, I had the opportunity to work as an intern at a golf course on the Big Island of Hawaii. During this experience, the superintendent of the course exposed me to a very interesting and troubling soil layering problem.

We first noticed thinning turf on the putting greens, especially in low areas where water collected. We found black layer in the top 6 inches of the profile (Fig. 1), 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.

Soluble iron moves downward through the profile until it reaches the pea gravel layer, where the water is perched.

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 cemented layer was almost impenetrable to water, which created anaerobic conditions in the root zone. As we continued investigating, we found this layer in every green we sampled, and anaerobic soil conditions were most prevalent in the low areas of the greens.

That summer, we experimented with physical removal of the layer. We used a sod cutter to cut two passes on the lowest edge of the green, where water was collecting. We dug down

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FIGURE 2

Iron layer at sand/gravel interface (12-inch depth) of Hawaii putting green. The layer reduced water infiltration, resulting in anaerobic soil conditions and thin turf density at the surface.

FIGURE 3

Iron layer in a Wisconsin putting green. The oxygenated pea gravel layer causes reduced iron in the root zone to oxidize at the textural interface. The darker black color is older, strongly oxidized iron; the light orange color is recent, weakly oxidized iron.

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to the pea gravel layer, removed the oxidized iron layer with a shovel and replaced the root zone with fresh sand. In the short-term, we were successful in improving water infiltration in these low areas. However, our fix was only temporary; the factors that caused the layer to form in the first place were still active, and the layer will likely form in these areas again over time.

One day, we were sampling and thinking about how the layer might be forming. We had many questions: "Where is this iron coming from? What factors are causing the iron to oxidize and precipitate at the sand-gravel interface? How do we remove this layer once it has already formed? How can we prevent it from forming in the future?" Finally, the superintendent suggested: "Go to graduate school, study this for your master's degree." That is exactly what I did.

UNIVERSITY RESEARCH

A few years later, I started graduate school at UW-Madison. The superintendent from Hawaii sent me some samples of this layer, and I confirmed that it was oxidized iron through physical and chemical analyses. I thought it was a rare, unique problem when I first witnessed it in Hawaii. But now that I've studied it more and more, I have seen this iron layer in Texas, Missouri, Virginia, Pennsylvania, West Virginia, California, North Carolina and even Vietnam. The layer seems to occur all over the United States and doesn't seem to be restricted to any specific climate zones.

When we take soil samples, we usually pull several plugs from the top 3-6 inches of the profile. From this, we get a wealth of information.

For my master's research, I am trying to find out exactly what causes this layer to form, how to prevent it and what to do if you already have it. The iron could be coming from fertilizer; high rates of iron fertilizer have become popular for *Poa annua* management programs, and many superintendents apply iron to improve turfgrass color. The iron could also be coming from irrigation water; many golf courses use groundwater that contains dissolved iron, and the amount of iron added through typical irrigation operations is comparable to typical iron fertility rates. Finally, iron could be coming from the dissolution of minerals in the sand used for root zone construction. Most likely, all of these sources

FIGURE 4

Full profile view of sand-based putting green using a PVC pipe sampling method. Note the oxidized iron layer at the sand/gravel interface (15-inch depth).

contribute to the formation of the iron layer to some degree.

Soluble iron moves downward through the profile until it reaches the pea gravel layer, where the water is perched. When 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 (Fig. 3). Over time, this iron layer becomes more cemented and water infiltration is severely reduced.

Currently I'm collecting soil samples from a number of courses with the iron layer across the U.S. I am also collecting irrigation water samples and fertility records to see if these factors have a relationship with iron layer formation.

THE IMPORTANCE OF FULL-PROFILE SAMPLING

When we take soil samples, we usually pull several plugs from the top 3 to 6 inches of the profile. From this, we get a wealth of information that can guide the application of fertilizer and soil amendments. We typically focus on the upper portion of the profile because this is where we find roots, thatch and potential organic layers. While this type of soil sampling can be useful, it may not be enough for two-tiered putting greens. When we only sample the top half of the profile, we are only getting half of the picture.

The lower half of the profile can have as many interesting features as the top 3 to 6 inches, and these features can drastically impact the performance of the putting green. If we hadn't sampled the full profile in Hawaii, we never would have found the iron layer. Our conclusion would have been to increase aerification and topdressing frequency, and we would have been unaware of what was really causing the problem.

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.) can offer a better view of the profile than the t-probe, but even these don't usually sample the full profile down to the pea gravel layer.

Dr. Norm Hummel offers a simple, effective and inexpensive method for collecting full-profile soil samples using PVC pipe (http://www.turfdoctor.com). With a handheld oscillating saw ($40-$100), the PVC pipe can easily be cut open for viewing of the full-profile (Fig. 4).

SEEKING SAMPLES

Are you experiencing this layering on your golf course? Know somebody else who is? We are currently looking for more samples, and we would be thrilled to include your site in our study. Please contact me at obear@wisc.edu for more information.

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