FEATURE I

Jerry Kershasky, *Reinders, Inc.*

Irrigation Water Quality

Charging, Flushing, Pulse Irrigation, Deep Infrequent

Long title, a lot of issues; let's see if I can guide you down a logical path to understanding the terms and possibly answering some of your irrigation water and watering questions. There have been more than a handful of times when I (a now-retired Superintendent of 37 years) have attended educational seminars where the presenting Turf Authority said, 'You (meaning all of us), in the humid Great Lakes Region, where rainfall is abundant, don't have issues with irrigation water. So, don't go spending money foolishly on a water sample analysis or on water and soil remediation products, because you don't need them.'

The first time I heard this, as a young Superintendent, I took these words to be gospel. Besides, who was I to question the message of this Turf Grass Authority? So, I did not sample my water. And really why should I? No previous Superintendent at my 1926-built course had, either.

My thoughts and thought process changed once I had a few wet and dry seasons under my belt. Seemed when we had consistent and timely rains my turf looked great, and so did the roots, but when I had to rely on my irrigation water, my turf slowly declined.

Why was rain water so good? We did not have Google, back in the day, so I jumped into the truck and drove off to the UWM library to gain some knowledge on rain water. The following is what I learned.

In some locations, rainfall has an acid characteristic. This is caused by nitrogen, sulfur, and some other compounds that are pollutants in the atmosphere. They become dissolved in mist that forms droplets of water during periods of precipitation. Since not all atmospheres are equally polluted with these substances, the amount of acidity varies depending on wind currents, which carry the pollutants in the direction of the precipitation event. Locations in the path of major air movements are most likely to have acid rain when pollutants are carried from sources down wind.

Just as irrigation water that carries calcium and magnesium will tend to reduce soil acidity, rain water tends to increase soil acidity. Rain water, regardless of atmospheric pollution, is acidic. Normal amounts of carbon dioxide in

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the air cause distilled water to be acidic, usually within the range of pH 5.6 - 5.8. This is caused by the formation of carbonic acid when carbon dioxide is dissolved in water. Rainfall through a non-polluted atmosphere has a pH in this range. This non-polluted rainfall is not a major cause of acid soils.

However, rainfall with nitric and sulfuric acid components may have a pH in the low 4.0s; this is acid rain. This is more than ten times more acid than in normal rainfall. At these hydrogen ion concentrations, soils become more acidic. In order to counteract the effect of acid rain, applications of ground limestone are needed.

A couple of notes here: First, smokestack acid scrubbers have greatly reduced the amount of true acid rainfall. Second, if you have been using urea sulfuric acid as an irrigation water treatment and using acid forming fertilizers it would be good to check the pH of your surface mat. Test the thatch layer alone, all by itself, no sand or soil with it. Next, sample separately the 1/2 inch of sand just below that mat/thatch layer. If either or both have become acidic, it may be a good idea to put a couple of pounds of lime down in the spring and fall. This could increase your infiltration rate and also reduce unwanted, accumulating organic matter.

Ok, if rainfall is acid and it is giving me some good looking turf, what's in my runoff pond and deep well irrigation water that causes the turf to decline? Also, who am I going to send the samples to, to have them analyzed? To a lab in Great lakes region, which has little experience testing poor water? Or, to a lab that routinely works with poor water? I choose the latter. In fact, I sent the samples to two people who had a lot of experience with this type of irrigation water and its effect on soils. First, I sent samples to Dr. David York at Tournament Testing lab. At the time, York was working with Karsten Turf, out of Arizona. Currently, his lab is in Valencia, Pennsylvania. The second was to Dr. Ron Duncan, at the time with the University of Georgia. Duncan is co-author with Dr. Carrow of the book, *Salt-Affected Turfgrass Sites, Assessments and Management*.[1] Duncan now has his own company, called Turf Ecosystems, LLC, located in San Antonio, Texas.

Here is his report.[2]

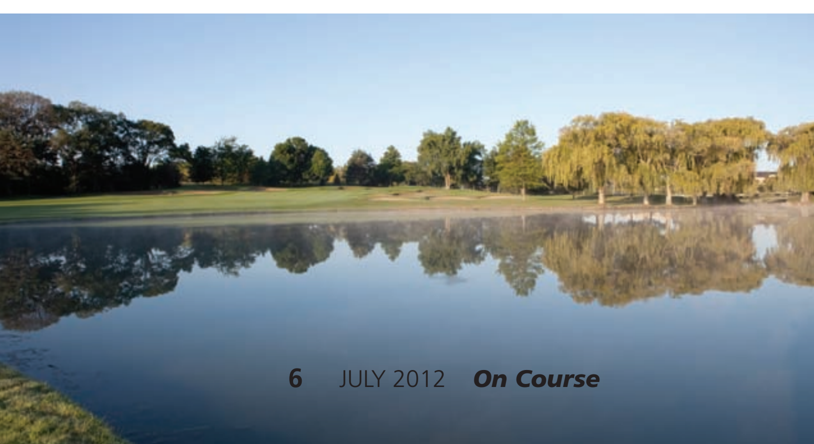
WATER

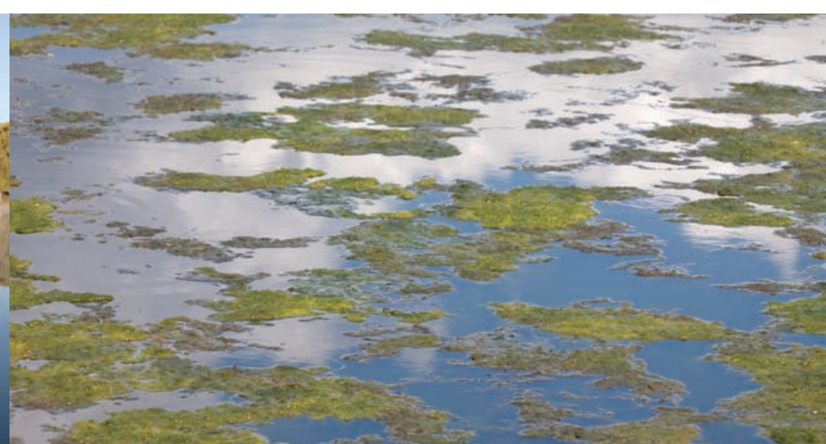
The major culprit here is the high bicarbonates/carbonates (Nov sample 5.25 meq/l well; 4.6 pond) compared with the Ca (4.2 well; 3.0 pond) and Mg (2.4 well; 2.6 pond). Na levels (0.9 well; 2.3 pond) are not high, but any precipitation of Ca and Mg will not leave sufficient levels to counter the Na, even if it is very low levels of Na. When the highway runoff moves into the pond (March sample), Na levels go up to 5.52 meq/L while your bicarbonate/Ca/Mg levels remain about the same. More and more Na will end up on the soil CEC, decreasing turf performance and increasing management budgets. The fact that the pHc is lower than the normal pH means more precipitation in the upper soil profile, leading to reduced percolation and drainage and more algae problems. Your ECw and TDS levels are good, but the problem is high bicarbonates. The only way to get rid of the bicarbonates is acidification (acid injection, acid fertilizers). This is worthwhile money spent.

SOIL SAMPLES

You need to maintain the following base saturation values:
65-85% Ca
1O-20%Mg
2-7% K
and less than 5% Na

Most of your soil samples are showing low Ca percentages and high K levels. Manganese is too low and needs to be supplemented (manganese sulfate is suggested, since you are low on sulfur too) this nutrient is critical for activating enzyme systems involved in photosynthesis and for disease suppression.





Where CEC is below 4.0 add zeolite to raise the CEC. Try not to let %OM get above 3% since it will hold excess Na. This reflected in the high %Na and low %Ca levels. The only way you get Na off the exchange sites is with Ca amendments. You seem to be maintaining high bicarbonate levels in the soils (+60%) which may be causing some layering and/or percolation problems. Acid fertilizers and removing any bicarbonates in the water are keys to preventing this problem from increasing.

Next, York's analysis of the pond:[3]

IRRIGATION WATER QUALITY ANALYSIS/POND

The analysis shows that the irrigation water has a USDA classification of C3-S1. There are several negative factors associated with this water. The water contains a high level of chlorides, a high level of sodium, a high level of bicarbonates, and a moderately high level of total soluble salts. The pH is alkaline and with the pHc less than 8.4 and less than the water pH, bicarbonates from the water may accumulate in the surface of the soil in the form of magnesium and calcium carbonates when this water is used to irrigate the golf course. If high levels of bicarbonates from the water precipitate on or near the surface of the soil, problems with water infiltration and penetration into the soil can occur. The applications of gypsum, soluble calcium, and humic acid to the soil along with acidification of the water and utilizing a penetrating wetting agent can be used to improve water movement into the soil. Maintaining a balanced soil chemistry and the applications of acidifying fertilizers are also beneficial in countering the accumulation of carbonates in the surface of the soil. Sodium, chlorides, and soluble salts from the water will have a tendency to build in the soil when this water is used to irrigate turf. Applications of granular calcium, soluble calcium, and humic acid will help counteract the accumulation of sodium in the soil. When this water is used for irrigation of golf turf, regular soil tests should be done to insure that sodium, chlorides, bicarbonates, and high levels of undesirable salts do not accumulate to unacceptable levels in the soil.

Houston, I have a problem.

An article by Carrow, Duncan, and Huck[4] reinforces the above recommendations. It came out in 1999, twelve years after I had started my irrigation water acid treatments and acid fertilizer program with the help of Dr. Tom Lubin, Chemistry Professor at Cypress College in southern California. The article talks about four situations that limit water infiltration into soils. I'm going to refer to two of these. The first is less likely to occur in the Greater Chicago area and the second one more likely. This is because of the water sources most of us use for irrigation and the calcareous, high pH sands we topdress with.

First, and less likely to occur: Moderate to high Na, high bicarbonate/carbonate.

High bicarbonate or carbonate content in irrigation water reacts with Calcium and Magnesium to precipitate insoluble lime. Even if the irrigation water contains little Ca or Mg, the bicarbonate and carbonate will react with any soluble Ca or Mg in the soil to precipitate lime. This greatly reduces the effectiveness of applied gypsum or S-source + lime (to create gypsum) by reacting with soluble Ca/Mg released from these amendments to form less soluble forms. This leaves excess soluble Na to increase the ESP (exchangeable sodium percentage) on the soil CEC sites without soluble Ca or Mg available to inhibit this process.

Under these conditions, even modest levels of Na can cause sodic soil formation with structure deterioration and, therefore, a reduced infiltration rate. Treatments of the irrigation water with acid to evolve the bicarbonate and carbonate off, as carbon-dioxide gas plus water, is highly desirable, because it allows any Ca and Mg in irrigation water to remain soluble and displace Na from the soil CEC sites. Treatment

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allows soil-applied amendments to be more effective in producing relatively soluble Ca, rather than being precipitated as lime. When irrigation water is acidified with a sulfur-based acid or a sulfur generator, it is important to effectively utilize the S to form gypsum. This can be achieved by adding lime to the soil surface periodically. Calcareous soils have free calcium carbonate that can serve as the lime source. However, over time the free calcium carbonate at the surface may become depleted, resulting in a reduction in the water infiltration rate. In this situation lime should be applied to the surface to maintain a Ca source at the soil surface to react with the S source.

Second, and more likely to occur: High Calcium/ Magnesium high Bicarbonate/Carbonate.

In this situation, the water contains unusually high Ca/Mg and bicarbonate/carbonate concentrations, but Na is absent or at low levels. As the bicarbonate/carbonate reacts with Ca/Mg, insoluble lime precipitates, often in the surface 1/4" to 1/2" of soil. It is not unusual to add 25-50 lbs. of lime per 1000 sq. ft. to turfgrass growing on acid soil. This may cause us to question whether lime formation from irrigation-water constituents really reduces infiltration and, if so, how. When limestone is applied, it is discrete particles, rather than a sheet-like layer at the surface, as occurs with irrigation water sources. Especially on sands, which have a low surface area, calcite coatings can form on particles and start to bridge between particles and fill the pores. This could create conditions where sealing of the surface would be possible and would cause reduced

water infiltration. However, sufficient calcite to adversely affect water infiltration would accumulate primarily under a combination of conditions such as:

- Sand soils with limited particle size surface area would be more susceptible than fine-textured soils.
- Irrigation water with unusually high bicarbonate and high Ca/Mg concentrations.
- Reliance on light, more frequent irrigation rather than deeper, less frequent applications. Light, frequent irrigation would favor deposition of the calcite at the surface under high ET conditions, while deeper, less frequent irrigation would favor calcite deposition near the depth of normal irrigation water penetration.
- An arid climate where high water use would result in considerable annual additions of calcite.
- A long growing season, including any winter overseeding period, that would result in high total water use over a year.

In humid regions, calcite buildup at the surface would be less likely, because the rainfall (low bicarbonate, Ca, Mg) would tend to dissolve calcite or at least move it deeper and disperse it throughout the soil profile. Also, annual additions of calcite would be lessened, because irrigation would be less frequent.

When the above combination of conditions favors calcite accumulation within the surface zone, is acidification of irrigation water a solution? The answer is yes, but not necessarily the best choice. For example, on some golf courses only the sand-based greens may show a decrease in infiltration, while the finer-textured areas do not. Treating the irrigation water for the whole golf course would not be necessary. In a contrasting example, the problem of high bicarbonate with high Na causes sodic conditions that adversely affect all soils. Acidification of the water for all areas of the golf course with that problem would, therefore, be important. In addition, a calcite layer is essentially a physical barrier to water infiltration; it could also be broken by periodic cultivation. The use of acidifying fertilizers, like ammonium sulfate or applying elemental S to the turfgrass surface, are an alternative. These would aid in dissolving the calcite layer by changing it into more soluble and mobile forms such as gypsum and lime.

CHARGING, FLUSHING

Prettyman and McCoy[5] explain "Charging and Flushing High-Sand Greens." This article should be read and reread to get a general guideline on water requirements to fully charge a green's root zone. It also explains the amount of water needed to accomplish the leaching fraction and complete flush defined by the volumetric water percent content readings of precharge, charge, and full flushing. Be aware the eaching requirements, for the purpose of moving salts out of the root zone area, are usually a smaller percentage of the leaching fraction, usually by a magnitude of 10-25 percent. The best way to get a handle on requirements for your greens is to get both a chemical analysis of your soil and a physical analysis of an undisturbed soil plug, cup cutter size. Send it to a lab to test for infiltration, percolation, bulk density, drainage, total pore space, and organic matter content.

PULSE IRRIGATION

The best explanations I have read on pulse irrigation to move salts out of the root zones came from Carrow and Duncan[1] (Chapter 8, Leaching of Salts and Water Management) and from Danneberger[6]. Here is a bit of information from both.

During droughty periods salts can accumulate in the root zone area causing stress to the plant. Salts can move up into the root zone through the process of evapotranspiration and capillary rise. Capillary rise occurs when irrigation or rainfall is insufficient in moving salts down or out of the root zone.

Surface and Subsurface cultivation: spiking, needle tining, HydoJecting, DryJecting, core and hollow tine aerating, deep tining—to name most, but not all—are essential in effective salt leaching. Irrigation practices should focus on moving total soluble salts downward. For this reason light, frequent irrigation is not recommended because salt buildup is rapid. Capillary action can cause salts to rise from the subsurface into the root zone. Cool season grasses are very susceptible to salt injury in the summer. If frequent irrigation is needed because of a shallow root system, frequent leaching will be required if rainfall is not timely or adequate. But if the weather is hot and humid, the leaching requirement should be only slightly more than the ET rate to avoid oxygen-depleted root zones. Hot humid conditions are NOT the times for charging and full flush operations!

Note: From Vargas at the MSU Turf Diagnostic Lab[7], "We often find over 1000 ppm of salt in the upper inch of samples sent to our lab for disease identification. Salt level that high in the upper inch of sand on a green will result in the green wilting and possibly dying."

Pulse irrigation events are short irrigation periods ranging anywhere from 5 to 30 minutes, depending on what the surface can infiltrate without runoff or ponding. Pulsing puts out anywhere from .08" to .4" water per cycle with dry intervals between 45 minutes and 2 hours. This pulsing is much more effective because pulse irrigation allows water to flow through the soil as unsaturated flow, which moves in a more uniform downward and lateral motion and occurs through the micropores. This is much more effective than heavy continuous watering which results in ponding. Ponding is saturated flow, which occurs mainly through larger macropores, resulting in inadequate leaching of the micropores.

When initiating a pulse irrigation program try to time it with a rain event to take advantage of the rain water quantity and quality.

A couple of other comments here: First, a USGA green, a California green with internal drainage, or even drainage lines that were installed in a pushup green (like a XGD install) allow you a significantly better chance of flushing your greens than without internal drainage.

Second, deep and infrequent irrigation started at the beginning of the season coupled with an aggressive cultivation and sand topdressing program will produce a deep root system that can survive and even thrive in some otherwise poor quality environments. A great read here comes from Miller's, "You Can Grow Better Turf with Less Frequent Watering."[8] Read this article each year in September, right after the summer stress period, and again in March, right before you fire up the irrigation system.

Seems like it is hard to break old irrigation habits, so it is good to have good information to read and reread before formulating your turf management and irrigation plan for the season.

Test your water and your soil. Without that information it is difficult to form a strong agronomic plan. **-OC**

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