



Carbonate and Organic Amendment Stability in Sand Putting Greens

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Prior to 2004, the USGA recommendations for golf putting green construction cautioned against use of calcareous sands. No mention is made of calcareous sands in the 2004 revised recommendations. The earlier concern was that carbonates in construction sands would decompose over time, releasing the silt- and clay-sized particles bound by the carbonates that would then adversely affect putting green porosity and water infiltration. Is it valid to ignore these possible effects of carbonates on the long term performance of sand-based putting greens?

Organic materials are commonly blended with putting green construction sand to increase water and nutrient retention. If the organic amendment in root zone mixes is subject to rapid micro-biological decomposition, the water and nutrient holding properties of the amendment would disappear over time and management strategies would have to be modified accordingly. This perceived instability in putting green performance is part of the logic behind construction of putting greens with pure sand root zones. Is this something we need to be concerned about?

In 1991, we constructed a putting green at the O.J. Noer Turfgrass Research and Education Facility with a calcareous sand and several different amendments. Analysis of these root zone mixes over time has afforded the opportunity to examine changes in carbonate and organic matter contents over a period of 10 years. A few of the properties of the organic amendments used in our 80/20 (v/v) root zone mixes are shown in Table 1.

Before looking at how carbonate contents in the root zone mixes changed over time, we posed the



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question "What would happen to the particle size distribution of calcareous construction sands if the carbonates decomposed completely?" To answer this question, we chose two widely used Wisconsin sands, one with 1.17% carbonates and one with 4.43% carbonates. We determined particle size distributions before and after destruction of the carbonates with acid.

The particle size analyses in Table 2 clearly show that the residual material from the carbonates was predominantly clay-sized particles. In sand #1 with 1.17% carbonates, destruction of the carbonates resulted in 5.0% in clay content of the sand, which is 2.0% higher than that recommended by the USGA. However, the sum of very fine sand + silt + clay did not exceed the USGA allowance of 10%, suggesting that for this low carbonate sand destruction of the carbonates may not have noticeable effects on putting green performance.

For sand #2 with 4.43% carbonates, destruction of the carbonates led to a particle size distribution that exceeded USGA allowances for clay and fine sand +

silt + clay by substantial amounts. In this case, it is not unreasonable to predict that carbonate dissolution in this sand has the potential for leading to putting green failure over time.

This brings us to the issue of carbonate stability in sand putting greens. Our analyses of several of the root zone mixes used in our study proved very interesting. In the first year after construction, the carbonate contents of the root zone mixes declined, but then increased gradually over 5 and 10 years (Table 3). The decreases in carbonates during the first year were proportional to the amounts of acidity in the various organic amendments (Table 1). Therefore, we surmise that it was the acidity in the amendments that led to breakdown of some of the carbonates in the construction sand.

The assumption is that carbonates in putting greens will be slowly destroyed by the acidity produced when microorganisms convert fertilizer-derived ammonium to nitrate-nitrogen. This did not happen in our study.

Table 1. Root zone amendment properties.

Amendment	Organic matter %	C:N ratio	pH	Acidity meq/lb
Sphagnum peat				
Canadian	93	53:1	4.0	203
Michigan	95	54:1	2.9	400
Wisconsin	83	50:1	3.3	213
Reed sedge peat	85	53:1	6.2	4
Fermented rice hulls	77	104:1	4.9	23

Table 2. Effects of carbonate destruction on construction sand particle size distributions.

Particle size	Sand #1		Sand #2	
	Original	- CO ₃ †	Original	- CO ₃ †
	----- % dry weight -----			
Fine gravel	0	0	0.1	0.1
Very coarse sand	7.6	6.4	5.5	2.0
Coarse sand	62.2	60.1	52.2	37.8
Medium sand	28.1	26.8	28.0	42.1
Fine sand	0.9	0.7	12.1	5.6
Very fine sand	0.5	0.2	0.8	2.2
Silt	0.5	0.6	0.5	1.7
Clay	0.2	5.2	0.8	9.4

† 1.2% carbonates in sand #1; 4.4% in sand #2.

Over 10 years, the carbonate contents of the root zone mixes progressively increased 11 to 36% (Table 3). The reason for this lies in the analysis of our irrigation water. As in all areas of the state where groundwater has percolated through limestone, well water has a high pH and correspondingly high concentrations of bicarbonates and calcium. Irrigation water at the Noer Facility typically has a pH of 8.2, a bicarbonate content of 310 to 360 ppm, and a rather stable 69 ppm calcium. It turns out that this irrigation water chemistry not only renders carbonates virtually insoluble, but actually favors carbonate formation. The bottom line here is anyone irrigating with high pH, high bicarbonate and calcium laden well water need not be concerned about the carbonates in their putting greens decomposing and liberating large amounts of clay-sized particles.

But what if you have putting greens constructed with calcareous sand and your irrigation water has a neutral or slightly acid pH? In this case, the primary source of acidity is the nitrogen fertilizer being applied. By making a few assumptions, one can calculate how much fertilizer N would be required to theoretically generate enough acidity to destroy all the carbonates in a given putting green. We won't burden you with the calculations, but simply note that for our construction sand with 1.17% carbonates, you would have to apply 4 lb N/1,000 ft²/year for about 50 years to generate enough acidity to dissolve all the carbonate in the putting green. For the construction sand with 4.4% carbonates (Table 1), the time frame is more like 185 years for complete dissolution.

Speaking of carbonates, you have probably heard the claim that high bicarbonate irrigation water causes calcium deficiencies due to formation of insoluble calcium carbonates. This concept is the

Table 3. Changes in the carbonate contents of various root zone mixes over time.

Mix amendment	Time		
	1 year	5 years	10 years
	----- % change in carbonate content †-----		
Sphagnum peats			
Canadian	- 8.5	+ 7.7	+ 35.9
Michigan	- 28.2	+12.0	+ 24.8
Wisconsin	- 6.8	+12.0	+ 24.8
Reed sedge peat	+ 0.8	+ 6.0	+ 13.7
Fermented rice hulls	0	+ 4.3	+ 11.1

† Based on 1.17% carbonates originally in the construction sand.

Table 4. Organic matter contents of various root zone mixes over time.

Mix amendment	Time		
	0 years	5 years	10 years
	----- % organic matter -----		
Sphagnum peats			
Canadian	0.64	0.52	0.48
Michigan	0.72	0.53	0.51
Wisconsin	0.96	0.62	0.49
Reed sedge peat	1.06	0.88	0.53
Fermented rice hulls	1.42	0.21	0.08

leading sales pitch for application of amino acid complexed calcium. Is this a valid claim? Absolutely not! There are two reasons for this. First is the fact that calcareous soils always contain and sustain much higher solution concentrations of calcium than do non-calcareous soils. Second, the amino acids complexing the calcium and purportedly preventing its precipitation as calcium carbonate are highly prized by soil microorganisms as nitrogen and energy sources. They are to soil microorganisms what a 16-oz prime rib is to a hungry golf course superintendent. The lifetimes of amino acids in soil are measured in hours to days, not weeks or months.

The rate of microbial decomposition of organic matter in soil is determined primarily by moisture supply, temperature, and the C:N ratio of the organic soil material. Given the frequency of irrigation of putting greens, we can discount

moisture supply as a limiting factor. The C:N ratio of the organic matter comes into play because when this ratio is above 30:1, the organic matter contains too little N to meet the needs of microorganisms. The soil microbes have to forage for other sources of nitrogen and this slows the decomposition process. As shown in Table 1, the commonly used putting green root zone amendments have C:N ratios well above 30:1. But with frequent, light applications of N, microorganisms should have little difficulty in finding adequate supplemental N. This leaves us with soil temperature as one of the most prominent factors controlling microbial decomposition of amendments. It is not just soil temperatures at certain times of the year, but throughout the year. Indeed, even sphagnum peat moss with its high C:N ratio has been found to undergo rapid decomposition in

subtropical and tropical climates.

What has not been clearly documented is the rate of decomposition of organic root zone amendments in temperate climates where soil temperature limits microbial activity for 5 to 6 months of each year. By measuring root zone organic matter levels over time, we found 10-year organic amendment decomposition rates to vary from 25 to 94% (Table 4). The Canadian and Michigan sphagnum peats were the most stable among those tested while the fermented rice hulls were very unstable. In fact, it became difficult to find even fragments of rice hulls in the root zone mix after only 5 years.

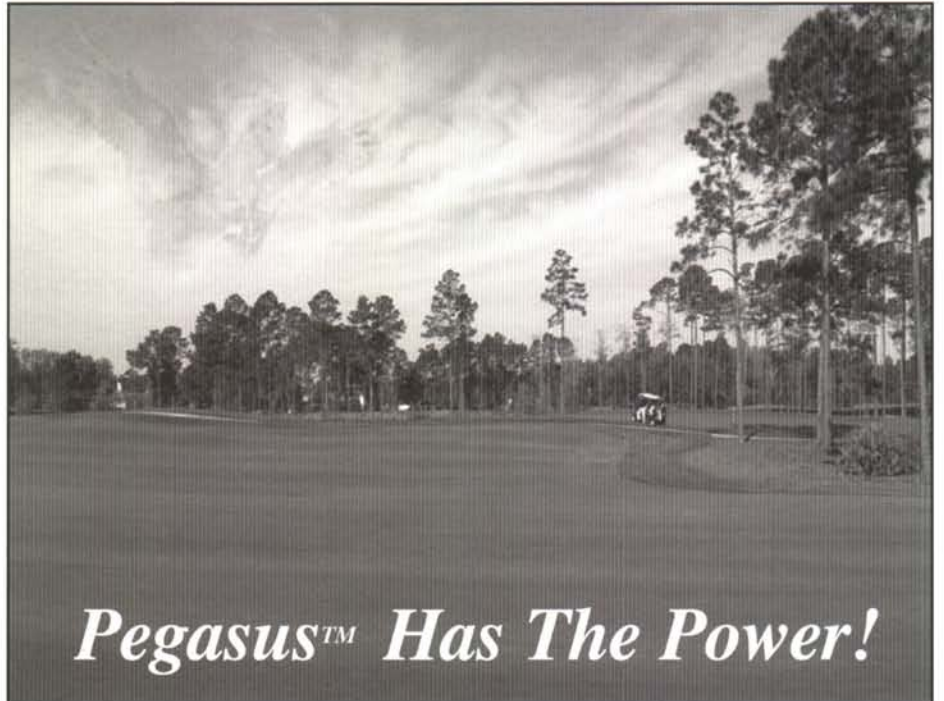
Rate of decomposition of the amendments tested slowed substantially after 5 years. This is to be expected because microorganisms attack those organic compounds from which they can derive the most energy from the decomposition process. What remains are compounds less and less susceptible to microbial composition. The compounds remain for long periods of time and are responsible for soil organic matter levels stabilizing over time. Judging from plots of percent organic matter versus years, we have arrived at the conclusion that organic matter levels in our putting greens would have stabilized after about 15 years. At that time, organic matter contents in the Canadian and Michigan sphagnum peat greens would be at 70 to 72% of their original levels. In the meantime, organic matter will have increased in the turfgrass rooting zone due to constant root dieback and regrowth.

Based on our observations, we see little reason to reject a putting green construction sand simply because it contains carbonates. Likewise, we cannot advocate not amending the sand with an organic amendment even though the root zone mix organic matter contents will transition over time to some-

what lower levels than in the original mix. Putting greens constructed with organically amended root zones are much more forgiving than pure sand. We had a pure sand root zone in our study that not only required overseeding and constant hand-watering during grow-in, but more precise N and K

management in subsequent years.

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