Zeoponic Turf Root Zone Systems

by Richard Andrews, James Shaw, and Dr. James Murphy

Bringing NASA-developed technology to sports turf

Sports turf managers are constantly fighting to keep their fields in top shape, despite routine damage from vigorous use and back to back events. It seems there's never enough time to allow fields to completely recover.

Now, a combination of science and a unique natural material is bringing a new way to speed turf establishment and improve recovery of damaged areas. The science comes from NASA, and the material is an innovative combined soil amendment and fertilizer.

NASA scientists have been working for years to develop a growth medium suitable for long-term space travel. Plants will be critical to this type of mission, since they provide oxygen and food, and can help recycle wastes.

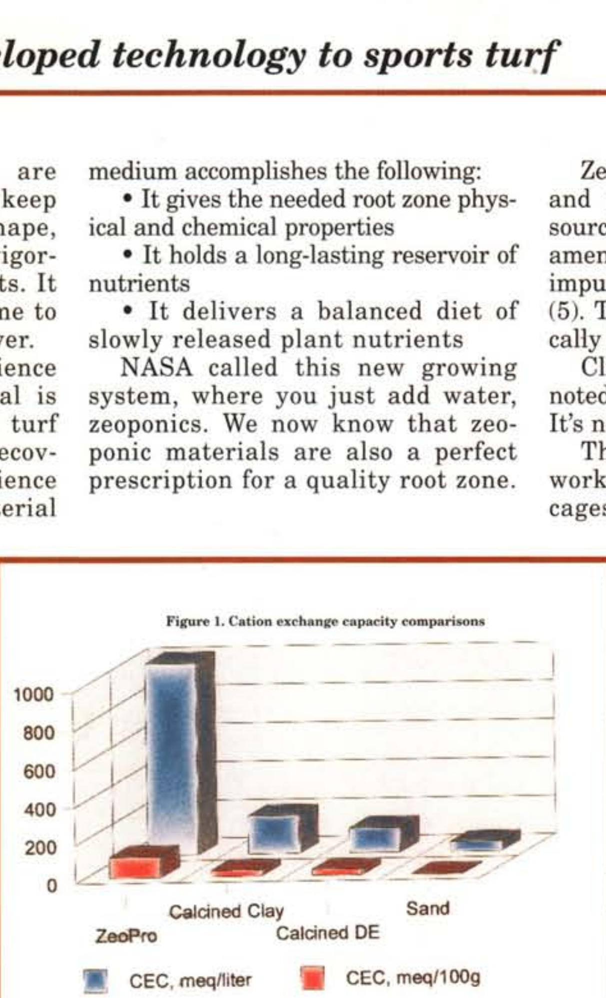
After years of research and testing, NASA developed and patented a unique growth medium using a type of zeolite, clinoptilolite, that is mined on earth from ancient volcanic ash deposits. NASA found that its high cation exchange capacity (CEC), high porosity, favorable moisture retention, and rigid structure made a superior plant growth medium.

High CEC allows the zeolite to be "charged" with essential plant nutrients such as ammonium-nitrogen and potassium. Combined with another key material called synthetic apatite, which NASA developed to provide phosphorus and trace elements, the new growth medium accomplishes the following:

- It gives the needed root zone physical and chemical properties
- It holds a long-lasting reservoir of nutrients
- It delivers a balanced diet of slowly released plant nutrients

NASA called this new growing system, where you just add water, zeoponics. We now know that zeoponic materials are also a perfect prescription for a quality root zone.

Figure 1. Cation exchange capacity comparisons



What is a zeolite?

Zeolite is the name of a class of minerals. There are about 50 that are naturally occurring.

Since zeolites are derived from volcanic ash sediments, they generally exist in areas where volcanic activity has occurred, such as the western United States. They are commercially mined, and the rock is crushed and sized during the process.

Zeolites vary widely in chemical and physical properties, and some sources are not suitable for root zone amendments due to sodium content, impurities, or poor particle integrity (5). The most abundant and economically important zeolite is clinoptilolite.

Clinoptilolite is an alumino-silicate noted for its rigid crystal structure. It's not layered like expansive clays.

The crystal structure has a network of interconnected tunnels and cages. Water can move in and out of these pores, but the zeolite framework remains rigid. Thus, zeolite-amended sand is capable of retaining more plant-available water than sand alone.

What really makes the material unique is its high CEC, which is in excess of 100 meq/100 grams. The cation exchange sites are located throughout the molecule-size tunnels and cages of the zeolite crystal.

This CEC property allows zeolite to hold nutrient cations, a property virtually absent in a sand-based root zone. Sand typically has a CEC of less than 2-3 meq/100 grams (see **Figure 1**)

What is zeoponics?

NASA combined the words zeolite and hydroponic to coin the term zeoponic. A zeoponic material is one that combines a nutrient ion exchange charged zeolite (a natural zeolite in which the ion exchange sites have been loaded with nutrient cations like ammonium and potassium) with slowly dissolving

Figure 2. Sand Based Amendment - Rutgers University
Test plot amended with 10% ZeoPro (left) compared to a sand-only control plot (right) 26 days after seeding bentgrass. Both received normal grow-in fertilization and management.

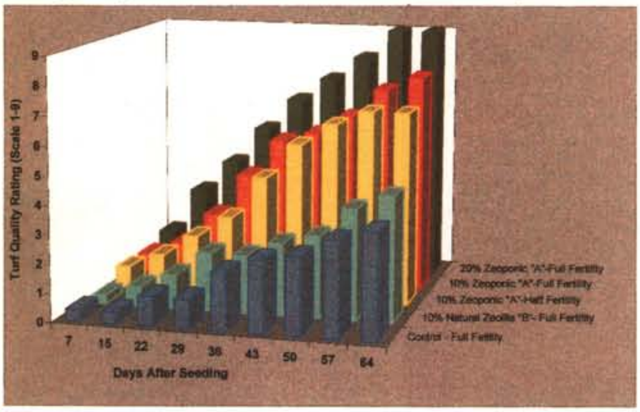
substances that contain selected nutrient anions (such as phosphates) and additional nutrient cations (such as calcium and micronutrients).

The charged zeolite interacts with the slowly dissolving synthetic apatite substance to provide N-P-K nutrients in slow-release fashion. It accomplishes this through a combination of chemical dissolution and ion exchange reactions.

The release of protons by the plant and uptake of nutrients from the soil solution by plant roots drive the dissolution and ion exchange reactions to release more nutrients as needed. In effect, zeoponic materials increase nutrient retention and reduce fertilizer requirements by establishing a replenishable and balanced nutrient supply in the root zone mix.

When amended into and partially substituted for sand or soils, zeoponic amendments also increase moisture retention because of the porous structure and high internal surface area of zeolite. Further, properly sized zeolite particles maintain or improve the root zone's ability to drain, provide aeration, and withstand intense traffic.

Figure 3. Bentgrass turf establishment • visual quality data • Colorado State University 1996



As testing and practical use shows, these materials help build an improved root zone that buffers turfgrass from environmental stresses, especially those associated with large fluctuations in moisture content and nutrient status.

Accelerated turf establishment

Whether you're dealing with new construction, field renovation, or repair, zeoponic materials enhance the establishment of turf and allow earlier use of the field. Tests at Colorado State University, Cornell University, and Rutgers University have all shown consistent high-performance results. Further testing is underway at

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other universities.

Zeoponic material amended into sand-based turf systems at 10 percent by volume have resulted in substantially faster establishment. Results have been measured in weeks or more.

In a USGA-sponsored program at Rutgers (1), the effects of site micro-environment, sand particle size distributions, and several inorganic amendments (ZeoPro, a zeoponic material; and Profile, a calcined clay) and organic amendments (peats) were evaluated during grow-in of creeping bentgrass on a USGA-type sand root zone. There were minor differences in turf establishment due to micro-environments and sand particle size distributions, but the really dramatic differences were with the amendments.

All of the amendments improved establishment compared to a sand-only system. Plots amended with zeoponic materials consistently established much faster as measured by turf density and quality.

At 30 days after seeding (DAS), the zeoponic-amended plots were rated 8.6 to 8.8 on a visual quality scale of 1 to 9 (1 = bare, 6 = acceptable, 9 = best). The other amendments ranged from 4.5 to 6.5, and the control plots (sand only) were rated from 3.0 to 4.0.

Figure 2 shows photos of a zeoponic-amended plot and the sand control 26 days after seeding. The zeoponic-amended plots maintained this substantial enhancement advantage over the entire 84-day rating period.

Turf research by Marty Petrovic at Cornell (2) and Tony Koski at Colorado State (3) compared establishment of zeoponic-amended plots and sand-peat root zone controls. **Figure 3** shows the visual quality ratings for the establishment period at Colorado State University in 1996. Virtually identical results were observed at Cornell University in 1998.

In both studies, even when zeoponic materials received only half of the normal establishment fertilization, they greatly outperformed the fully fertilized, sand-peat root zone control plots.

Acceleration of turf establishment has been documented in other studies for bluegrass-ryegrass blends, bermuda, zoysia, and bentgrasses, irrespective of whether they started from seed, sprigs, or sod. Root mass development has been documented (Colorado State) to accelerate greatly. When only half the fertilizer was applied, five- to 10-percent amendment levels produced more than twice the root mass development of fully fertilized, conventional sand:peat (90:10) root zones in the first 90 days (3).

Reduced nutrient leaching

The difference in turf performance with zeoponic amendments is believed to result from more uniform nutrient delivery. The nutrient-release reactions in the root zone provide a steady stream of nutrients. Sand-based systems cannot hold nutrients in this manner, due to lack of cation exchange capacity.

Extensive and frequent use of fertilizer can allow the turf manager to come close to the performance of a zeoponic-amended root zone. However, a large fraction of applied nutrients in a sand system leaches through the root zone and becomes an environmental issue.

Not only does zeoponic material allow use of less fertilizer, the zeolite also picks up excess applied nitrogen and potassium ions in the root zone (essentially recharging the material). This results in lower leaching losses to the environment. University research has shown this reduction in nutrient loss to be in the range of 65-95+ percent for a root zone amended with 10-percent zeoponic amendment.

Improved root zone characteristics

Zeoponic material also improves the root zone's physical characteristics. Properly sized zeoponic material should improve infiltration, porosity, resistance to compaction, and water holding/release characteristics.

Many physical amendments improve these characteristics in sand-based root zones. Zeoponic materials have been shown to be equal or better than any of them for amendment of soil physical properties. However, zeoponic materials are three- to 25-times higher in CEC compared to other inorganic amendments.

James W. Shaw is president and Richard D. Andrews is CEO and research director of ZeoponiX, Inc. of Louisville, CO (www.zeoponix.com). NASA has patented its zeoponic material and licensed its manufacture exclusively to ZeoponiX, Inc.

Acknowledgments:

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4. Andrews, R.D., A.J. Koski, J.A. Murphy, A.M. Petrovic. "Zeoponic materials allow rapid greens grow-in." Golf Course Management, Vol. 67, No. 2, Feb. 1999.

5. Allen, E.A., and R.D. Andrews. "Space age soil mex uses centuries-old zeolites." Golf Course Management, Vol. 65, No. 5, May 1997.Figure 1. CEC comparison graph.