Guest Editorial

Who Is Tending The Store?

I have become involved in the restoration of a 100 year-old building in the centre of the city in which I live. This involvement has illustrated the number of loops city officials require those involved with renovations to jump through. Permits and approvals must be obtained for structural changes, electrical changes, plumbing alterations, fire coding, fire exits, and health standards—just to name a few. All are necessary to ensure the building standards of the city are adhered to and that some unscrupulous contractor does not use faulty designs, procedures, and materials.

I have, on occasion, seen faulty designs, procedures, and materials used in the construction of sports fields. As a result the owner, and usually the taxpayer, has been saddled with extra expenses which could have been avoided if some inspection or supervision had taken place during the construction or restoration of the field.

In a recent review of a proposal for a major Ontario city, I raised the question of site supervision during a field restoration process. I was somewhat surprised to receive the response, "We do not require inspection on site." I raised the point that if the restoration was for a new changing room, most of the same group of inspectors I have dealt with on the old building restoration would have descended on the site. When asked why a sports field does not require inspection whereas a change room does, I received the response, "Buildings have provincial and federal standards which must be adhered to."

Is it not time then that we developed minimum standards for the construction of sports fields? The standards could be the first step toward minimum standards performance of the field. At the very least, we should require inspections to assure that the taxpayers' money was spent wisely.

— Dr. Bob Sheard

ATTENTION ADVERTISERS

If you are looking for a specific market for your products, advertise in *Sports Turf Manager*. Published four times a year, this newsletter has a national and international distribution with the majority of its membership residing in Ontario. 1999 advertising rates (per issue) are as follows:

- business card size $40.00
- 1/4 page ad $80.00
- 1/2 page ad $160.00
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For more information, contact Lee Huether at the STA office, (519) 763-9431, or Joy Black at New Paradigm Communications, (519) 371-6818.

♦ For more feature articles from the 1999 Ontario Turfgrass Symposium, please see pp. 6-11.

♦ For the dirt on grubs, see pg. 13.

Weather Facts

Once in a blue moon? No, twice. A blue moon rose January 31 and again on March 31. Two blue moons in one year happens every 20 to 40 years. The last time was in 1961.

The term "blue moon" refers to the occasional occurrence of two full moons in the same month, which usually happens roughly once every 33 months. The last full moon was January 2.

The second full moon in a month is called a blue moon, regardless of tint.

"Having two full moons in two months in one year is really kind of nifty, no matter what you call them," said Jack Horkheimer of the Miami Space Transit Planetarium.

The next occurrence of two blue moons in one year will be in 2018, on January 31 and March 31, and again on the same dates in 2037.

— Associated Press, The Record, February 1, 1999

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STA OFFICE HOURS

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Snail Mail & E-Mail

Periodicals Donation

I am writing to thank the Sports Turf Association for the donation of a variety of periodicals to the GTI Resource Centre.

The periodicals have been used to fill some of the gaps in our collection as well as to expand the titles available in the area of sports turf management. Any duplicate periodicals had articles clipped to expand the information in the subject area files we maintain in the resource centre.

The GTI Resource Centre is used by researchers, GTI staff, the OMAFRA Turfgrass Specialist, students, and members of the industry. Your contributions will assist us in providing this important service.

Thank you again for your continued support of the Guelph Turfgrass Institute.

— Rob Witherspoon, Director

STA Grass Seed List

Every second year your newsletter puts together a list of grass seed (species and cultivars) available for sale from the major seed companies in Ontario. I would like to commend the Association for doing this. I know that it is a lot of work, but it is a very useful piece of information. I find that I refer to it often during the year and I also send it to my clients for their use. Please keep up the good work.

— Pam Charbonneau, OMAFRA

Maintenance Standards

I would like to ask if you have developed a sports field maintenance standards handbook similar to the ORFA Refrigeration & Ice Making Manual. I am in possession of your sports field construction and maintenance booklet. Is this your standards booklet as well? I believe if we were to meet industry standards, we would be in a more defendable and therefore marketable position.

Please update me on anything new you may have available so that we may improve our service and end product.

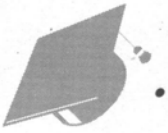
Keep up the great work. For an organization that started out so innocently, you have come ... kilometres! Thank you for all of your publications and information.

— Mark Fluhrer, Manager, Parks Services, City of Kingston

Editor's note: Please see the guest editorial "Who Is Tending The Store." While standards are not available at this time, the information garnered through STA resources (print and people) will assist the athletic field manager in providing better, safer sports turf. Thanks for your kind comments.

Content deadline for the September issue of Sports Turf Manager

JULY 15, 1999



Congratulations

- ***Gordon Bruce, City of Mississauga***

STA Scholarship Winner
November/December 1998 Turf Managers' Short Course

- ***Howie Kumagai, City of Toronto***

STA Scholarship Winner
February 1999 Turf Managers' Short Course

PLEASE NOTE

The opinions expressed in articles published in *Sports Turf Manager* are those of the author and not necessarily those of the Sports Turf Association, unless otherwise indicated.

CHRISTOPHER MARK

The President's Desk

Hello! I extend a happy spring/early summer to all members. I'm sure everyone is at their absolute busiest right now and well into their athletic field maintenance programs for 1999. I hope everything goes according to plan!

I would like to thank all members who have renewed their annual dues with the Association. We appreciate your loyalty and ongoing commitment to the STA and our mission of better, safer sports turf. If you have not yet remitted your dues, we would appreciate you doing so at your earliest convenience. Also, please take the time to review your membership data we have on file. If incorrect, please inform us to ensure our records reflect accurate members, positions, and contact information.

The Board is very busy finalizing plans for the Field Day to be held on August 18 at the GTI. Once again, I extend my sincere appreciation and thanks to our supplier members who have generously sponsored so many of the day's activities. Your assistance is invaluable. Make plans to join us on August 18 for what promises to be an exciting and informative day. Included with this issue of *Sports Turf Manager* is the Field Day brochure. With Dan Ferrone, President of the CFL Players' Association and former captain of the Toronto Argonauts, and Ken Mrock, Head Groundskeeper for the Chicago Bears, we are expecting a record attendance. Don't delay in completing the application form to ensure your registration.

In other news, a Board sub-committee is laying out the groundwork for another great sports turf component at the OTS 2000. Don't forget to include the OTS in any year 2000 educational budgets you may be preparing or providing input towards in the coming months.

Congratulations to our educational scholarship winners, Gordon Bruce from the City of Mississauga and Howie Kumagai from the City of Toronto. Both were top graduates of sports field related subjects at the University of Guelph Turf Managers' Short Course. Mr. Bruce was the Fall 1998 recipient and Mr. Kumagai was the Spring 1999 winner. We are pleased to honour both of these outstanding gentlemen. They will be invited to our Field Day to be officially recognized and introduced.

Speaking of outstanding gentlemen, I was very pleased to hear that Dr. Henry Indyk has been selected as SportsTurf's Man of the Year. Dr. Indyk has long been recognized as one of the leaders in sports field design and maintenance and has been a wonderful ambassador for sports turf. We have had the pleasure of Dr. Indyk addressing our Association at a previous Field Day and he has also been a presenter at the OTS. He has always been viewed as one of the more forward thinkers and innovators in our industry. Our congratulations to Dr. Indyk on his very deserving achievement.

I wish everyone a wonderful, safe, and pleasant summer at work and on vacation. Wishing you better, safer sports turf,

— Christopher Mark

STA Membership Dues

Thank-you to all members who have renewed for 1999!

If you have not already done so, please ensure you are a member in good standing by remitting your fees today. Don't forget to return your Member Information Form. The STA Membership Roster is compiled from the information entered in our database. To contact the STA, please phone (519) 763-9431, fax (519) 766-1704, email sta@gti.uoguelph.ca, or snail mail 328 Victoria Rd. S., Guelph, ON N1H 6H8.

The Service Department

Equipment Maintenance And Safety

Take pride in your equipment and tools. Keep them very sharp and balanced, well lubricated, even over lubricated if possible, and you will save power and therefore fuel. *We* all love to save money!

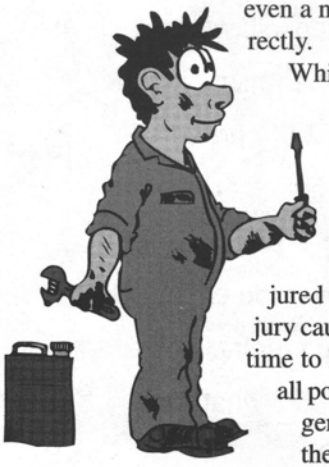
When pruning trees, shrubs, or flowers, it is quite noticeable when the proper tools are used. When they are very sharp and in good condition, the job is much easier. This is the same for turf grass equipment. A well-maintained yard, golf course, green, or ball park is a delight to see, so keep your equipment clean and sharp.

Due to humidity, rain, and plant moisture, rust will progress constantly. We can only overcome this process with thorough maintenance. Naturally, all machinery will perform much better without rust.

On the safety side, do not let anyone use a machine without proper training. Eli Luster advises reading the operator's manual before working on equipment. Procedures and performance schedules have been tested under actual operating conditions and have proven that it's worth both the time and effort needed to perform them. *If you put off reading the manual, you'll likely need it later to see what should have been done, or what must be redone.*

Use the right part. The proper type and size part and the proper hardware allow the part to do the job for which it was intended. Don't make substitutions. Hardware used in power equipment is chosen for a purpose. For example, the shear bolts (soft, breakaway bolts) frequently used to attach accessories, will break away when an object becomes lodged, freeing the attachment from the gear box or drive shaft. If a hard bolt is substituted, the accessory remains attached even when an object becomes trapped, forcing the unit to continue operating and transferring the stress and damage to a more expensive part of the machine.

Little things do count. Even simple parts, like belts, must fit correctly. Contrary to popular belief, "will-fit" parts may not be the same as original equipment parts. If a belt is worn or too small, there will be belt slippage, reducing the effective operation of the machine. Worn or wrong-sized belts can cause wear that changes the physical shape of the sheave. If this occurs, even a new, properly-sized belt won't fit correctly.



While keeping your equipment in good repair, pay very close attention to the safety equipment found on all machines. Do not tie off or jump safety switches or levers. They are there to help keep operators from getting on the list of people that have been injured or even died while on the job. An injury caused by a machine usually takes a long time to heal. Make sure shields are covering all power takeoffs. They are extremely dangerous, especially when children are in the vicinity.

Remember to keep fuels properly mixed and stored in marked and clean containers. Many experienced workers have installed the wrong fuels in gas, mixed gas, or diesel engines. Check air pressure in the tires and oil in the engine.

The first thing you do when you begin your day and the last task you perform at the end of the day is to circle check your equipment. This will save you money and give you pride in your machinery. You will be pleased with the many problem-free hours you will experience due to good maintenance. Have a great summer! ♦

— Allan Gray (with help from Eli Luster)

Eli Luster's passages from "Equipment Maintenance for Sports Turf Managers," Turf and Landscape Press, March 1995 as reprinted in Sports Turf Topics: A Compendium of STMA Articles, 1995-1996.

OTS Conference Highlights

Sportsfield Drainage: Learning From Mistakes (Case 2) by Dr. Bob Sheard ♦ Tired Soil: Using Inorganic Soil Amendments to Perk up Your Root Zone by Paul Grünthal

Sportsfield Drainage: Learning from Mistakes (Case 2)

DR. BOB SHEARD, P. AG., AGRONOMIST, GUELPH TURFGRASS INSTITUTE

An Ontario soccer club was successful in raising money to develop an outdoor sports facility designed to have several soccer fields. Provincial and municipal support was received contingent on the club obtaining the necessary environmental clearances and providing the city with a site development plan. A landscape architect was engaged to provide the necessary clearances and plans—plans which met with city approval. Following this initial work, few financial resources were left to develop the first field. A sketch of the soil profile and minimal directions were provided to the club by the architect.

The architect suggested removal of the surface 15 cm of topsoil, which was a clay loam, shaping the field to 2.0% grade at centre field for drainage, placing a 10 cm layer of sand over the entire field, and then replacing the topsoil (Figure 1).

During late April and early May, spring fertilization and mowing of the establishing grass were delayed due to wet conditions on the field. Any maintenance operations which were attempted resulted in severe rutting by the tractor. Later in July and August, the field became very dry and hard as no irrigation was available and the grass was in poor condition. Turf outside the field, however, remained in relatively good condition as rather timely rains were experienced throughout the area.

Coring revealed the subgrade below the sand layer was not penetrable with a hand soil probe.

What Went Wrong?

There were two major errors in design and construction. The major problem was the sand layer below the topsoil which created two zones of pore size discontinuity. The first zone was between the subgrade and the sand layer. At the interface of the subgrade and the sand there is a change from relatively large pores in the sand to very small pores in the subgrade. As often happens in sports field construction, the earth moving was done in the fall under wet conditions with large-size, earth moving machinery. This operation resulted in a compacted subgrade with further reduction in porosity through which one would expect a very low rate of water movement. Thus, winter snows and spring rains would keep the sand layer saturated for a long time in the spring. In turn, the water in the saturated sand layer would rise into the topsoil by capillary action, keeping the surface soft and resulting in the observed rutting by the tractors.

The second zone of pore size discontinuity occurred at the interface between the sand layer and the topsoil. Here the discontinuity is in the reverse direction where relatively fine pores in the topsoil overlay large pores in the sand. Initially in the spring, drying out would be delayed because a perched water table would develop in the topsoil at this interface, adding to the wetness of the surface. When the system finally dried out during midsummer, capillary flow of water from the subgrade upwards through the sand to the topsoil would be interrupted resulting in the turf having to rely only on the available water stored in the 15 cm of topsoil.

The second error in the design was the use of an excessive crown as a substitute for drainage. Although a 2.0% grade would effectively shed most of the water if the field were a bare parking lot, a dense turf, the prime prerequisite of a good soccer field, is the best system known to soil conservationists to prevent run-off. If run-off is prevented through the turf cover, the water which falls on the surface must infiltrate the soil surface and be removed by natural or artificial internal drainage systems. While a crown may be of value in a parking lot, it adds little to the drainage of a sports field.

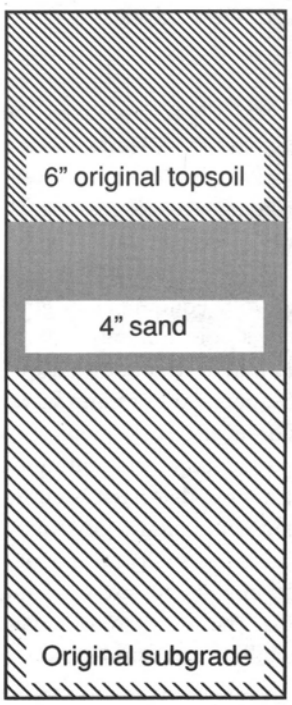


Figure 1: A schematic drawing of the soil profile of the soccer field.

The architect suggested removal of the surface 15 cm of topsoil, which was a clay loam, shaping the field to 2.0% grade at centre field for drainage, placing a 10 cm layer of sand over the entire field, and then replacing the topsoil. So, what went wrong?

Fixing the Problem

The solution to their problem is expensive. The sand layer must be removed. To do so requires that the topsoil be carefully stripped from the field and stock piled before the sand is removed and discarded. Some intermixing of the soil and sand is unavoidable where the stripping is done with large equipment.

The question is asked: "Why not mix the sand and soil together"?

There is a grave danger in mixing the topsoil and sand together in that the resulting mix will be very highly compactable and the field will have very poor water transmission characteristics. It is also very difficult to obtain a good blend of soil and sand unless the material is passed over a power screen and the moisture content of the materials during screening is appropriate to allow good fragmentation of the structure of the topsoil. Satisfactory mixing cannot be achieved with a rotovator or by deep cultivation.

When designing a soccer field, it is best to stay with the soils which were left there by nature unless you understand the physics of water flow in soil. As with any major surgery, it is advisable to get a second opinion. ♦

"When you come to the end of your rope,
tie a knot, and hang on."
— Franklin D. Roosevelt

Tired Soil: Using Inorganic Soil Amendments to Perk up Your Root Zone

PAUL GRÜNTHAL, M.SC., EPI

Poor growing conditions are often the result of problem root zones. Compaction, lack of structure, or inadequate porosity are just a few of the stresses that can reduce the productivity of your soil. Landscapers, sports turf superintendents, and nursery owners are constantly striving to find solutions for stressed, tired, and compacted root zones. Soil amendments are proving to be invaluable tools for enhancing some of the most common soil problems.

Compaction

Mechanical forces from cultivation or heavy traffic move soil particles closer together. Compaction destroys natural soil structure, increases the bulk density of the material, as well as creates numerous other problems. As more force is added, the number of larger pores begins to decrease and the movement of air and water is restricted. This is especially true for fine textured soils—soils with a high percentage of clay and silt-sized particles.

The inherent properties of some soils may make them more vulnerable to compaction. Soil, water content, type and amount of clay or organic matter, and particle-size distribution can all determine the susceptibility of soil to compactive forces. Severe compaction leads to poor drainage, lack of soil aeration, and restricted root growth. Therefore, it is important to understand how you can manage the forces on top of your soil and the physical properties in your soil.

The Need for Structure

Soil structure also influences the movement of water and air in the soil. The term soil structure refers to how primary soil particles (sand, silt, and clay) are arranged into aggregates. Plant roots, wetting/drying, or freezing/thawing cycles move primary particles closer together. Sticky residues from microbes, organic matter, iron oxide, and clay then act as cementing agents and hold the particles in place. The amounts and types of binding agents will determine the stability of the aggregate.

Clearly a soil with a well developed crumb-like aggregate structure will contain a lot of large pores creating the best pathways for exchanging gases, moving moisture, and growing roots. A soil with an abundance of large pore spaces will also occupy a large volume and hence have a lower bulk density when compared to a poorly structured soil of the same type.

Problems with Porosity

Adequate pore space is essential to a healthy soil environment. Air and water move through the root zone via spaces between solid soil particles and soil aggregates. Porosity is vital for plant transpiration, nutrient uptake, and root movement. However, knowing the total porosity of your soil is not as important as knowing the ratio of pore sizes. Pore space in the soil is generally divided into larger and smaller pores.

Larger pores are vital to drainage and remove excess water from the soil to allow aeration of plant roots. For this reason, large pore space is often referred to as aeration porosity. Smaller pores hold water needed for plant growth. Water in smaller pores cannot be drained by gravity, but is slowly taken up by plants along with nutrients. Networks of tiny pores can move water upward like the wicking effect of small tubes. This characteristic gives this void space its name, capillary porosity. However, there are limits. Very tiny pores may hold water so tightly that they are unavailable for plant use.

Preferred ratios of air and water filled pore space vary with the application of the growing media (Figure 1). Generally, the total porosity should occupy about 50% of the volume of the root zone. The remaining volume consists of solid mineral and organic materials. Several analytical methods can be used to measure the relative ratios of pore space in soil. However, most techniques require the use of suction or tension apparatus to draw water from the soil. Laboratories or universities specializing in soil analysis can usually provide this service.

Uses for Amendments

Poor soil fertility can be corrected easily using fertilizers or organic amendments. Nutrients are added when needed. However, without the right soil composition, those nutrients may not be enough to satisfy all of the plant's needs. A good root zone will provide physical properties necessary to optimize all the constituents required for growth.

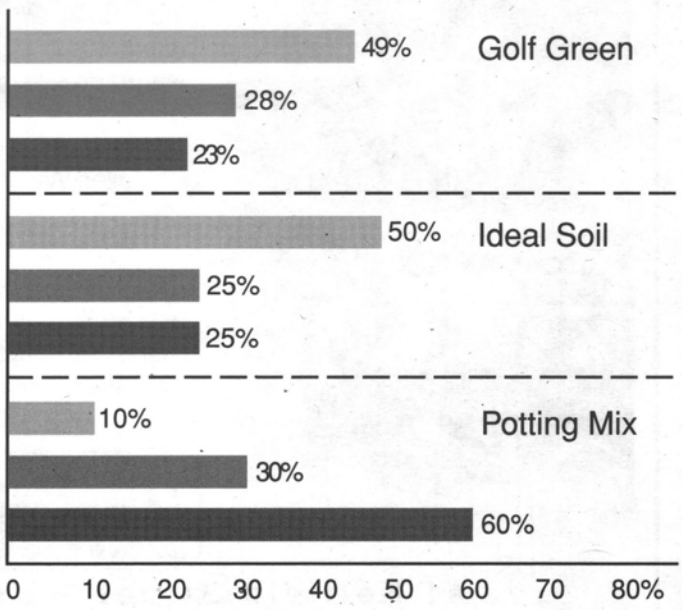


Figure 1: Preferred ratios of air and water filled pore space. water air solids

Generally, soil amendments are used to improve plant growth by enhancing the physical characteristics of the root zone. Superior drainage, better gas exchange, and increased tilth optimize access and use of soil nutrients by plants. Continuing interest in the management of problem soils has led to the commercialization of numerous products. Amendments can be split into three categories: organic supplements, soil conditioners, and inorganic amendments.

Organic amendments from plants or animals are the most commonly used. They supply nutrients to the soil, aid soil structure, and are often considered a hybrid between a fertilizer and a soil amendment. Most people have used organic supplements such as manure or compost. However, waste-based supplements from food and industrial processors are receiving more attention. Now your plants can dine on grain by-products, crab and fish meal, and beer residue.

Synthetic materials and starches are often referred to as soil conditioners. They can be designed to increase water absorption, stabilize soil aggregates, and control erosion. Conditioners such as surfactants, polysaccharides, and humic derivatives are all useful tools to the horticulturist.

Typically, the third category consists of inert granular material. Sand, heat-treated minerals, plastics, and rubber are designed to influence soil texture and improve its physical characteristics. Inorganic amendments can reduce the bulk density, break-up heavy soils, and enhance the number of large pores in the soil.

Table 1: Common Amendment Properties

Amendment	Bulk Density (g/ccm)	pH	CEC
Sand	1.45 - 1.70	4.5 - 8.5	Low
Vermiculite	0.07 - 0.12		High
Perlite	0.10 - 0.14	7.0 - 7.5	Low
Calcined Clay	0.60 - 0.80	6.0 - 8.0	Low-medium
Diatomite	0.39 - 0.70	7	Low-medium
Zeolite	0.48 - 0.85	8	Medium-high
Expanded Shale	0.80 - 0.95	6.8 - 9.5	Low
Pumice	0.09 - 0.20	7.0 - 7.4	Low
Slag	0.70 - 0.80	High	Low
Crumb Rubber	0.44 - 0.46	6.7 - 6.9	Low
Polystyrene	0.02 - 0.03	7	Low

Choosing your Amendment

The main objective of most coarse inorganic amendments is to create more pores. Increasing the amount of large pores will promote drainage and aeration, while enhancing the soil's capillary porosity will aid water retention. Some soil amendments also have a high cation exchange capacity (CEC) which can help prevent nutrients from being leached out of the root zone.

Some experts believe the choice of soil amendment should be based on its ability to improve soil aggregation and structure. Others debate that the most important characteristics of coarse amendments are their particle size, uniformity of particle size, and durability. Another view is that the most efficient amendment is the material that can provide the greatest improvement of soil characteristics per unit volume or weight. However, some amendments are more effective for enhancing one particular property. The amount of supplement added also depends on the texture and relative state of the soil you are amending.

In short, there is no cure-all amendment. However, there are a number of factors to take into consideration before buying an amendment. Below are a few areas to examine when purchasing a soil amendment:

Stability

Is the material physically, chemically, and biologically stable?

Materials that breakdown or change shape due to compaction or weathering may slowly lose their ability to enhance the soil's physical conditions.

Consistency

Is the product of consistent quality?

Uniformity from batch to batch provides you with assurance that you will get the desired result when applying the amendment at the manufacturer's suggested rate.

Suitability

Is the supplement physically and chemically suitable for your needs?

A material that is difficult to handle, hard to mix, has an unacceptable pH or CEC may lead to unanticipated problems.

Viability

Is the material readily and economically available?

The product should be easy to obtain and relatively inexpensive. When examining costs remember to amortize the benefits of the product over its estimated life span. Unlike fertilizers, inorganic amendments are designed for the long-term.

Amendments

More and more amendments are being introduced into the marketplace under various trade names. Manufacturers use different processes, feedstocks, and quality control methods to produce their materials. Variability in production along with a wide range of products can make choosing an amendment a difficult task. If you are unsure about a certain product ask the manufacturer for more information, talk to colleagues who have used the material, or consult an expert. Table 1 outlines some of the properties of common inorganic amendments.

Sand

Sand is the most commonly used amendment. It is available from a wide variety of sources, obtainable in many grades, and is inexpensive. Coarse, well-graded quartz sand with the proper pH and few weatherable impurities is preferred because it is chemically stable and highly resistant to physical weathering. The high bulk density of sand makes it ideal for adding weight to soil-less mixes. Sands also enhance air porosity and water movement, but decrease water retention. Their effectiveness is largely dependent on their particle size distribution and sometimes large quantities must be used to achieve the desired effect.

Processed Mica

Vermiculite is a layered mineral that is crushed and graded before it is heated to expand (exfoliate) the particles. Exfoliated vermiculite has a very high water holding capacity. In fine-textured soils this amendment can enhance water movement and air porosity, however, in coarser mediums vermiculite can have the opposite effects. It is a major constituent in most soil-less mixes because it has a high CEC, contains potassium and magnesium, and aids rewetting. Vermiculite is extremely vulnerable to collapse from compactive forces and will break down when mixed wet.

Perlite

Perlite is a porous, lightweight, siliceous material produced by quickly heating obsidian-like volcanic rock. It is chemically inert and resistant to weathering. However, perlite is also brittle and can be crushed by compactive forces. Its low bulk density makes it useful for reducing the weight of container mixes, such as those used for roof top gardens, but particles often float to the surface upon irrigation. Fine grades can effectively increase total porosity and water retention in soil. A coarser material can improve aeration porosity but is not thought to be as effective as other amendments in increasing permeability in fine-textured soils.

Calcined Clay

Heating (calcining) clay minerals such as montmorillonite and attapulgite to extremely high temperatures creates these porous ceramics. Calcined clays are available in a variety of grades and are used frequently as industrial absorbents and cat litter. Coarse grades are suitable for renovation work or potting soils while finer materials are generally used for top-dressing turfgrass. Calcined clays can increase aeration and drainage in finer soils, but these benefits may be reversed when added to some sands. They are extremely porous and can hold large volumes of water. Unfortunately, materials with a high percentage of very small pores hold water so tightly it may not be available for plant growth.

Diatomite

This amendment is made by calcining diatomaceous earth, a silica-based mineral derived from the skeletons of diatoms (microscopic algae). The lightweight granules are stable and relatively inert. This amendment is available in a number of particle sizes and shapes. Fine materials are designed for topdressing turf while coarser particles are more suitable for landscaping or speciality mixes (i.e. orchid and bonsai). Diatomite is effective in increasing aeration porosity and drainage in fine soils and improves capillary porosity in coarser root zones. Similar to calcined clay, however, if the majority of pores are very fine then not all of the water held will be available to plants.

Zeolite

Clinoptilolite zeolite is a naturally occurring aluminosilicate mineral. It has a porous crystalline structure that helps to retain plant available water, reducing water consumption. Well-graded material can also aid drainage. Zeolite has a high CEC, which increases nutrient retention within the soil and can reduce leaching of potassium and ammonium. Nitrogen is more efficiently used by plants because zeolite reduces ammonium conversion into the more leachable nitrate form. The most desirable zeolites are those that are derived from deposits low in sodium.

Expanded Shales

Heating shale to extremely high temperatures produces crystallized, expanded particles. When properly graded, these particles can increase soil aeration and infiltration. Shales can also have a high CEC and provide some nutrients. Their high pH should be considered when using large quantities of material.

Pumice

Pumice is a siliceous and remarkably porous volcanic rock. Fine grades increase water retention in fine-textured soil while coarser materials enhance both total porosity and air porosity. Pumice can enhance permeability and its amendment characteristics have been compared to those of perlite.