FUNCTIONS AND MOVEMENTS WITHIN PUTTING GREEN SOILS

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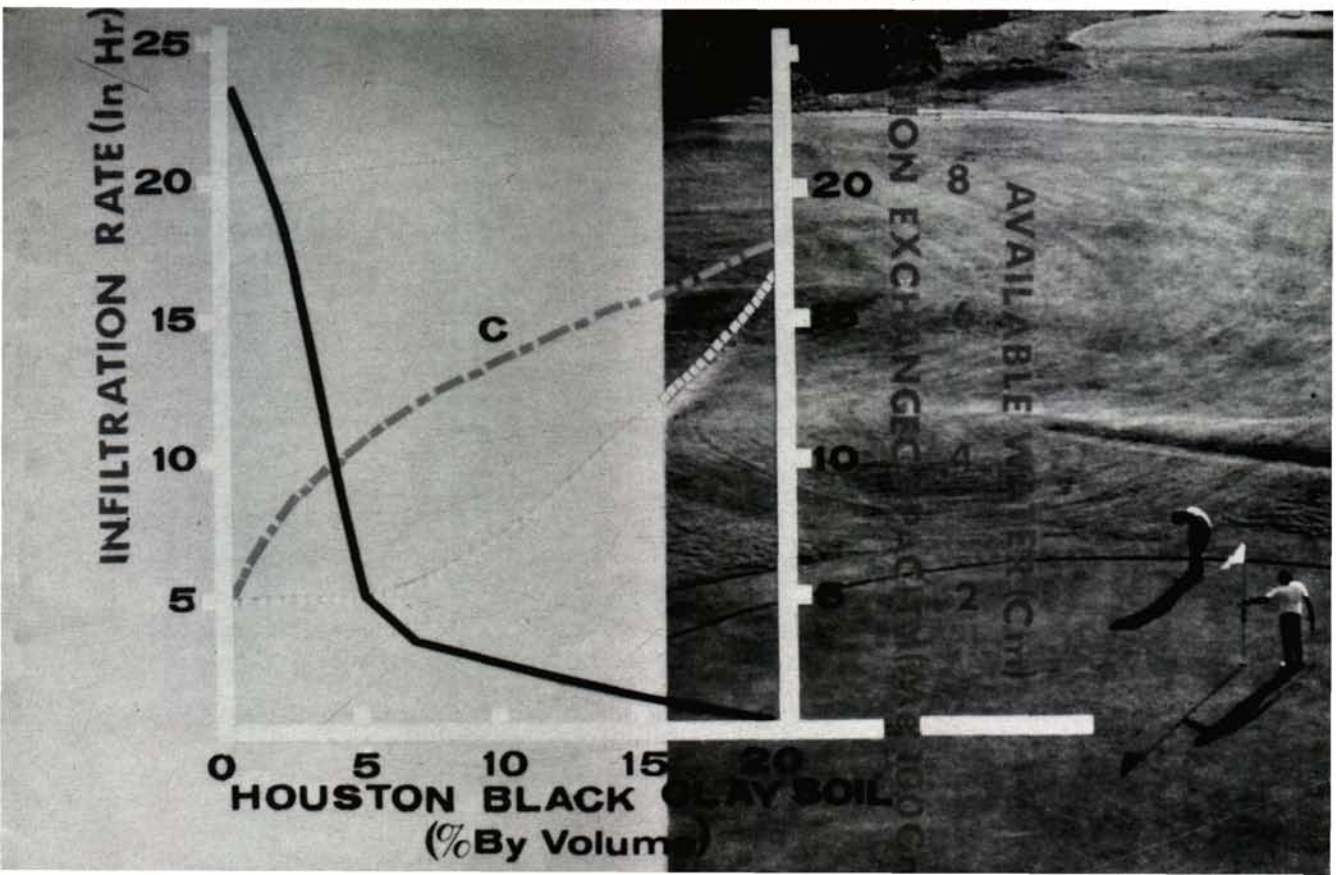
For many years now the Green Section has been studying putting green soils. First we sought to determine what comprises a suitable soil mix, and now, what goes on inside it. This latest study has taken on more importance in light of environmental concern and its residual regulations.

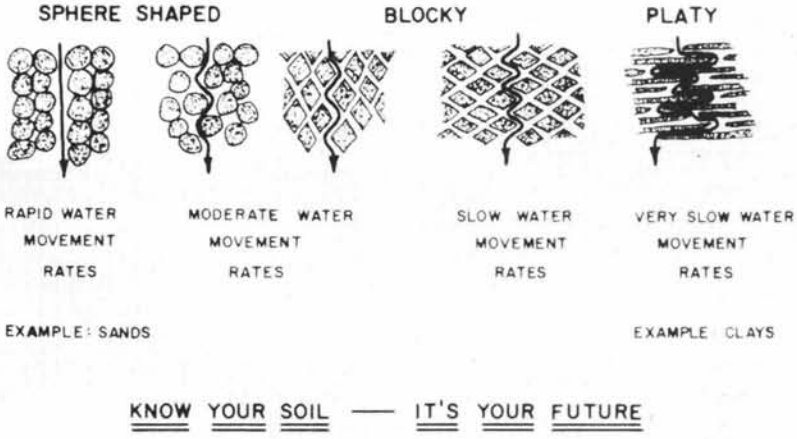
Functions within a soil in this instance refers to such things as biological activity, cation exchange capacity, root penetration, and the exchange of gases with the atmosphere and within the soil itself. These are functions of the soil *per se* or of agencies within the soil acting upon it.

Biological activity is probably least understood and an area in which our studies must overlap into the field of pure biology and bacteriology. My nephew pursued a post graduate degree in biological physics. He was so far inside the surface of plants and soils that his reports were akin to biological science fiction. Although not bodily transported, he nevertheless literally was being transported through plant parts and soil particles. The paper he sent me titled, "The Dimerization of Chlorophyll A,B,C and Bacterio-Chlorophyll' was of little practical value to my immediate interests in making grass turn green by applying nitrogen, but no doubt will someday be easy reading for turf students.

We should be concerned with the *biological activity* of soils on a practical level at this point,

Result of soil component and water movement studies at Texas A&M University show greatly reduced infiltration, an increase in cation exchange capacity, and greater moisture holding capacity as the clay content of a soil is increased. This graph clearly indicates the undesirable effect of too much clay in a soil mix.





The effect of soil particle size and shape has great influence on water movement.

however, because biology refers to life, and life within the soil has a tremendous influence on our success in growing turf. Hopefully we can find ways of increasing favorable biological activity and surpressing other forms.

The effects of pesticides on soil life have not been investigated extensively, but will no doubt be a fertile field for future study. The soil contains many organisms from microscopic bacteria to earthworms. The earthworm is a beneficial organism for the soil, but it is undesirable for golf greens because of their casts on the putting surface. Less desirable is the parasitic nematode, but even certain types of these microscopic animals can be beneficial in the soil. Most of the other soil bacteria and fungi is at least partly beneficial and concerned with such things as nitrogen fixation and the transformation of organic matter to humus. To aid the beneficial organisms in the soil, we should maintain a desirable soil pH, proper aeration and proper moisture.

Cation exchange capacity of a soil is a measure of the soil's ability to absorb, store and release nutrients. Some of the more recent methods of putting green construction advocate almost pure sand, which has a very low CEC (cation exchange capacity). I don't believe this is a really critical factor, however it has never been more important than now with limited or nonexistent fertilizer supplies at extremely inflated prices.

The USGA Green section has always thought that a putting green should have a small amount of soil (clay) in the mix; the figure is probably near 5 per cent by volume. This not only increases the cation exchange capacity, but also the moisture retention and possibly enhances the activity of microflora.

Root penetration of a soil is exactly what we hope for. The root itself excretes powerful acids from the region near the root tip which helps decompose soil solids such as rock. We have often heard the expression that a turf can produce its own soil. In many ways that is exactly what happens. Even when the soil is near ideal to start with, such as on a properly prepared putting green, the root penetration helps to keep it properly aerated and influences the amount of organic matter and humus present. In most cases, all three functions are beneficial.

The exchange of gases with the atmosphere and within a soil is a vital process. Oxygen is probably the most important of the gases, because it is essential for every living organism. Proper aeration, through mechanical methods, proper watering and proper mixing of prepared soils cannot be over-stressed. We have direct control of all these procedures and the natural aeration of roots, earthworms, and the like are incidental.

Turf roots need almost as much air-filled pore space as moisture filled pore space to grow properly. We have more exactly specified the range of tolerance of turf in this area within recent years, but the first figure I ever saw of 25 per cent air, 25 per cent water, and 50 per cent solids for best plant growth is still correct enough for practical purposes.

Dr. Marvin Ferguson first told me of it, and later I saw published information stating that bentgrass can survive on the oxygen in fresh water. Be sure that the oxygen in trapped water is quickly depleted in the presence of living organisms such as turf roots, so I emphasize *fresh* water.

No matter how much pore space we put into a soil mix originally, the pore space remaining after compaction will determine its adequacy. Because of this, the intended use of the area is an important consideration in determining how porus a soil has to be to produce good turf. In most cases, proper pore space is obtained by adding the correct amount of properly sized sand.

Proper components and their correct use in construction are a key factor in green construction and turf manageability thereafter.

Most of the functions just described within a soil are closely related to and overlapping with the movement of moisture, soil solids and soil additives also taking place within the soil.

The movement of soil moisture basically is described as infiltration, the movement of water into a soil; percolation is described as the movement of water through a soil. The rate of infiltration and percolation is influenced primarily by the size and distribution of soil pores and the shape of the soil particles. Water moves much faster through large pores than through small pores, because of cohesive as well as adhesive forces which are greater in the smaller pores. The large pores are important for the rapid movement of water into and through a soil as well as for proper aeration. The shape of the soil particles, whether sphere shaped, blocky or platy, also has an influence on the rate of moisture movement and aeration. Sands are typically spherical in shape encouraging more rapid moisture movement, as opposed to clays which have platy characteristics and slow down moisture movement. In order to get sufficient movement of moisture (drainage) as well as sufficient capacity for moisture retention for use by the plant, it is necessary to select or manufacture a soil with the proper amount of both large and small pores. This in itself is a big order, but we are also looking for a soil with good nutrient retention (high cation exchange capacity) and one which is resilient after compaction. This can be best done only by a laboratory equipped to perform a thorough physical analysis as described in the USGA Green Section's publication, "Method of Putting Green Construction."

Soil layering can cause many problems with water movement.

With soils on the golf course other than the putting greens or tees, we must either try to select the best soils on which to build, or as it is more often the case, resort to mechanical aeration as a means of introducing adequate pore space.

The movement of soil solids influences the physical structure of soils over a period of time, and we are highly interested in this activity, because it influences the productive longevity of soils. Movement of soil solids could completely change the nature of a soil and its ability to grow plants.

Studies at Texas A&M thus far have given no indication of significant movement of soil solids. This research, however, is really just beginning and it is far from conclusive. Earlier studies have definitely shown movement of smaller particles such as silts and clays into larger particles below such as sands and gravels if the particle size differential was greater than five to seven times the particles above. This knowledge is rather useful in installing french drains or ordinary drain lines as well as in mixing and constructing putting greens. I would hate to count the number of times I have seen drains fail on golf courses simply because this fact was unknown or ignored. There is certainly

Many factors can cause shallow rooting in turf, especially poor watering practices and a soil which has inadequate drainage. In this case a water leak from an irrigation valve in the center of the green separated the turf mat on top from the roots below. The turf rolled up like a rug.

no useable pore space in rock, and the useable pore space between them is quickly filled with smaller particles which may or may not have sufficient pore space for good drainage if there are no barriers.

The movement of soil additives has to do with the leaching or dissipation of such things as nutrients and pesticides. Once again, the other factors discussed come into play, especially cation exchange capacity, biological activity and moisture movement.

Cold fear gripped the public in the last three or four years when stories of thin egg shells, diminishing wildlife species and pollution of human food and water hit the papers. The move toward eliminating this pollution would no doubt have also eliminated recreation, wildlife, business and ultimately the human race if left unchecked in the hands of the alarmists.

We have every reason to fear pollution, but let's not go beserk until we have decided just what pollutants are and how best to cope with them. Anything without the proper checks and balances can be detrimental. Increasing population is a pollutant source, but let's not adopt Hitler's techniques for solving it.

For the past three years the Green Section has sponsored studies on the movement of nutrients and pesticides through putting green soils because of the concern about waste of nutrients through leaching and the harmful residues and lechates containing pesticides. The studies indicate that many of our fears are unfounded, especially concerning mercury and arsenic. In most cases these two elements do not run off or leach through the soil in quantities declared unsafe for human consumption by the federal government when used in the amounts normally recommended for turf work.

The loss of nutrients is relatively minor and most times necessary to maintain proper drainage and aeration. Nitrates in lechates can be harmful, but as yet the general feeling is that the benefits outweigh the detrimental effects.

The interaction of soil additives with the soil and with each other is relatively unresearched, but what little is known about the exchange of ions between particles is another story in itself. At a practical level, we are most concerned with keeping the soil pH in a favorable range for the optimum exchange and utilization of these elements.

Most of the information presented here is common knowledge or readily available from turf texts, but it is my hope that some additional information has been added and the entire article presented in such a way as to invoke some thoughtful practical applications.