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to generate acidity, it can generate anaerobic soil and lower soil redox potential. Research was conducted to help illustrate this point.

When elemental sulfur was added to a water-logged turfgrass soil at a rate of 1.5 pounds or 3 pounds per 1,000 square feet, it depressed both pH and redox potential significantly. Research was also conducted to illustrate how keeping redox potential elevated can prevent formation of sulfide. Data says applying elemental sulfur significantly reduced redox potential and resulted in formation of high levels of sulfide. Applying nitrate with the sulfur kept redox potential poised at a point high enough to prevent the release of sulfide. This occurred because the presence of nitrate maintains an Eh of plus 0.43 V, higher than required for sulfate reduction to occur. But when the nitrate is depleted, redox potential falls.

Organic matter can also lower redox potential as it stimulates microbial respiration by acting as a food source for microbes in the soil. The respiratory activities of the microbes consume $O_2$ faster than it can be replenished. As another example concerning organic matter, natural and organic sources of N (sewage sludge) must nitrify to release the nutrient N. This involves reacting with $O_2$. This process, which scavenges $O_2$, is known as nitrification.

## Keeping high redox potential

There are several ways to keep soils from becoming anaerobic. This requires an integrated approach involving frequent aerification and other cultural practices. Make sure to vary the nature of the aerification tines and depths of penetration. Failure to do so can generate what is called a "plow pan," which restricts diffusion of oxygen into the soil, generating low redox potential. The integrated approach also requires that topdressing events utilize appropriately sized materials, and that frequency is suitable to prevent development of layers within the soil profile.

Small-diameter sands may work into putting greens very well but can also create physical problems, such as perched water tables if the particle size does not match base materials. Perched water tables can be great generators of low redox. Do what is possible to encourage drainage, including mitigating both surface and subsurface drainage problems.

Inadequate drainage is a main cause of low redox, as water impedes diffusion of $O_2$ into the soil by a factor of 10,000 times compared to a relatively dry soil. Surface soils need a minimum of 1 to 2 percent slope to drain effectively, and all putting greens should drain in at least three directions. Subsurface drainage needs a minimum of 0.5 to 1 percent to drain, and be sure to daylight drainage out of high traffic/play areas so as to avoid ponding.

If low redox conditions do begin to develop as indicated by the appearance of black layer, fertilize with nitrate-based sources of N. The nitrate molecule is such that adding it to soil effectively adds oxygen, which poises redox at a point high enough to temporarily prevent most low-redox related problems. In addition, don't apply natural organic sources of N or elemental sulfur. Both of these materials scavenge $O_2$ creating a low redox potential, hence unfavorable growth conditions. Fertilizing with nitrate and withholding applications of elemental sulfur are best management practices for preventing low redox and associated black layer.

Understanding the chemistry and math behind redox potential is not important for turf managers. But what is important is having a thorough understanding of the implications of having a low redox potential and how to avoid it.

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