Effluent Irrigation, Part II: The Agronomics

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So you've decided to be a good neighbor to your community and look into using effluent water for irrigation. You've learned about how water is recycled. Primary treatment removes much of the solid material, both organic and inorganic. Secondary treatment removes up to 90% of the remaining organic matter, though it still contains large quantities of nutrients and other inorganic constituents. Tertiary water is best for your course: non-biodegradable organic matter and much of the nutrient content has been filtered from the water by passing it over activated charcoal. Tertiary water is also the most friendly type of recycled water from a human health perspective since most of the coliform bacteria have been removed. But all is not necessarily well. With more golf courses every day feeling the pressure to turn to effluent for irrigation, it's important to know what you're getting yourself into, and what you're getting into your turf.

Properly treated tertiary effluent will still contain solids, microbes, organic compounds, and dissolved inorganics such as salts and nutrients like nitrogen and phosphorus. If considering using effluent for irrigation, check the water quality first. Effluent water quality will vary among locations. Items to check for include pH, dissolved solids, salts and sodium, bicarbonates and carbonates, and heavy metals.

Total suspended solids (TSS) should be less than 5-10 grams per liter. Water with TSS can eventually clog surface pores and inhibit infiltration, causing puddling, algal growth, and other drainage-related problems. Management practices may have to change to include more frequent core aeration, spiking, or slicing to enhance drainage. TSS should not be confused with turbidity measurements which are often included in standard water tests. Turbidity is merely a measure of the light transmission through the water. Although dependent on the particulate matter suspended in water, no standard guidelines have been developed to determine acceptable turbidity levels.

Irrigating with effluent will likely affect your fertility program. Effluent contains a variety of nutrients including N and P. The algal blooms in your ponds may not be from your fertilizer, but rather from your irrigation water! You'll have to monitor your water source regularly, usually monthly, since nutrient loads will not be constant. Nitrogen levels may range from 10-35 parts per million (ppm), phosphorus from 0-5 ppm, and potassium from 5-25 ppm. Calculate the nutrient loads monthly to determine how much to change your fertility program as shown below:

1) Find the concentration of the element such as N or P from your water quality test

Results are typically given in ppm or mg/L.

2) Multiply the concentration by 2.72 to give lb nutrient per acre-foot of applied water. One acre-foot is 43,560 ft^3, equal to the volume of water contained in a prism one foot high with a one acre base, roughly 325,000 gallons.

3) Divide the value from #2 by 43.56 to determine the lb nutrient per 1,000 ft2 turf area.

For example, assume a water test reported 1) 6 ppm N; 2) 6 x 2.72 = 16.3 lb N per acre-foot of water; 3) 16.3 lb N/acre-foot divided by 43.56 = 0.374 lb N/1000 ft^2. Thus, one acre-foot of this effluent would supply 1/3 lb N per 1000 ft^2 of turf area. This nutrient loading adds up: A typical 18 hole course may use 300,000 gallons of water on a hot summer day, equivalent to over 90% of an acre-foot of water, or about 15 lb N/acre added to the turf if the effluent contains 6 ppm N. The EPA standard for drinking water is 10 ppm, an amount which even tertiary water may exceed. For those superintendents living in a community concerned about nutrient runoff, effluent irrigation may not be doing anyone a favor unless proper steps are taken to avoid excessive nutrient loading.

If you've ever been out West you may have seen some of the famous "salt flats", areas where salt has become so concentrated little vegetation will grow. Users of effluent, no matter where they are, could face a similar situation if steps aren't taken to avoid salt buildup. One of the items to check in the effluent water test report is salinity level. Salinity levels are determined by using an electrical conductivity (ECW) test which measures the ability of the water to conduct electricity. The more salt, the greater the conductivity. Conductivity measurements will be shown in units of decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm). Total dissolved salts (TDS) may be listed in ppm. High salt concentrations in soil reduce turf growth by witholding water from plants: the high salt concentration lowers the soil osmotic (or solute) potential, preventing water from being attracted to the plant roots if they have a higher osmotic potential. Affected turf may be prone to wilting on hot and/or windy days even when the soil is still moist. Leaf tips may appear scorched. Over time the turf thins out and loses uniformity.

The USDA has classified salinity into four levels. Low salinity (less than 0.25 dS/m), medium (0.25-0.75 dS/m), high (0.75-2.25 dS/m), and very high (> 2.25 dS/m). Turfgrass breeders are focusing more closely than ever on salt-tolerant species such as alkaligrass which is tolerant of salinity exceeding 10 dS/m. Research is being conducted on genetically modifying turfgrasses with a gene known as BADH to confer salt tolerance to salt-intolerant, yet commercially desirable varieties. Perennial ryegrass has good salt tolerance and can tolerate 6-10 dS/m. Tall fescue, Chewings fescue, and creeping bentgrass generally can tolerate 3-6 dS/m though genetics of individual cultivars plays a strong role: 'Seaside' creeping bentgrass is much more tolerant than 'Penncross' and 'Penneagle'. Kentucky and annual bluegrasses have poor salt tolerance (< 3 dS/m).

Sodium levels are often excessive in saline water. Sodium is not an essential plant nutrient and can damage plants and soil structure when present at high levels. Sodium causes loss of soil structure by displacing larger ions such as calcium and magnesium, resulting in a breakdown of soil aggregation (a process known as "deflocculation"). Sodic soils have talcum powder-like properties: water literally beads on the soil surfaces which significantly reduces infiltration. A good water test report will include the Sodium Absorption Ratio (SAR). The SAR estimates the sodium hazard and relates sodium levels to calcium and magnesium. The greater the number the greater the risk for poor soil structure. Values of less than 10 meq per liter pose little danger to soils, while water with a value above 24 meq per liter is not suitable for irrigation. Use of irrigation sources with values between 10 and 24 meq per liter may be acceptable but will require special management techniques to avoid salt and sodic-related problems.

Sodic soil problems can be remedied but are likely to be time-consuming and costly. Applications of gypsum may be used to supply excess calcium to dislodge sodium ions from the soil. The sodium combines with the sulfate in the gypsum, forming water-soluble sodium sulfate which can be leached from the soil. Over a period of years the soil structure can be improved, though its best not to let it get this far. On putting greens, the maximum amount of gypsum that can be safely applied is 0.5 to 1.0 lb per 1000 ft^2, while up to 300 to 500 lb per acre can be applied to fairways. Rates should be based on soil and water tests. Foliar burn potential can be reduced by spreading gypsum applications over several months of cool weather.

Effluent water can also pose problems with carbonate ($CO3^{2-}$) and bicarbonate (HCO_3^-) ratios. Carbon dioxide, produced by root and soil microbial respiration, reacts with water to form carbonic acid (H_2CO_3). Normally carbonic acid is not a problem. When effluent water with a high pH is used, the bicarbonates and additional carbonates in the water bond with calcium and magnesium in the soil to form lime. This situation allows sodium to adsorb onto the soil peds, causing deflocculation and loss of soil structure. Hard water can also increase soil pH over time, potentially causing elements such as iron, manganese, and zinc to become unavailable for turf uptake. This problem can usually be remedied by using chelated and/or foliar appliciations of micronutrients. Hard water problems can be reduced by injecting acid into the irrigation system. Acid injection uses sulfuric, sulfurous, or phosphoric acids to reduce the water pH. Although acid injection does not correct sodium problems directly, it does keep the calcium and magnesium solubilized and prevents lime formation in the soil.

Heavy metals are the final type of contaminant to check for in effluent water sources. Heavy metals are especially likely to be present if the effluent contains water affected by heavy industry or mining operations. Some urban areas may also add heavy metals such as cadmium,copper, nickel and zinc. At excessive levels, any micronutrient can be toxic to plants. Chlorine and boron are problems in some areas and their toxicity effects have been more rigorously studied than some of the other micronutrients. Both accumulate in leaf tips, causing burn which can fortunately be removed by mowing. The clippings need to be collected and discarded, preferably being spread out so as not to concentrate the elements in another area. Trees and shrubs can also be sensitive to excessive chlorine (above 350 ppm) and boron (above 2 ppm) levels.

Author's note: This is the second installment of a three part series on effluent irrigation. The first installment was published in the July/August issue. The final installment will cover regulations, including the logistics, of handling effluent water and best management techniques to avoid some of the problems presented in the current article.