TURFGRASS IRRIGATION WITH WASTEWATER

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The focus of this article is to provide an overview of turfgrass management concerns related to wastewater use – the issues that a turfgrass manager must understand for optimum turf culture. Turfgrass irrigation water quality guidelines for chemical constituents in the water are similar to those used for other crops with some refinement and guidelines are available on the websites: (www.usga.org; then go to the USGA Green Section Record issue noted in references 4 and 5) and (www.turfgrasswater.com; then go to the water quality sections and guidelines where reference article 2 is located). A good irrigation water quality test determines constituents in the water, namely:

GENERAL WATER CHARACTERISTICS

WATER PH. This is a concern only if the pH is unusually alkaline or acidic.

Bicarbonate and Carbonate Content. These ions react with Ca and Mg ions in the water to form lime in the soil or in some unusual situations in irrigation lines. The lime is not harmful and many turfgrasses are grown on calcareous soils. In a humid climate, lime additions to the soil are often needed. However, when irrigation water has appreciably Na ions that may create sodic soil conditions (soil structure deteriorates), alleviation requires relatively high levels of moderately slow-release Ca, such as from gypsum, $CaSO_4$. If bicarbonates and carbonates are present in high quantities, the result is lime formation where the Ca in lime is very slow-release in comparison to gypsum; and these ions in the soil can also cause soluble Ca released from gypsum to be tied up in the lime form. The net result is insufficient soluble and moderately slow-release forms of Ca to displace Na from the soil cation exchange sites (CEC) and Na carbonate precipitates. It is in these situations where acidification of irrigation water is recommended to dispel the bicarbonates and carbonates as CO_2 gas from the water.

NUTRIENT AND ELEMENT CONTENT

Wastewaters generally contain more nutrients than potable water, and some contain appreciable nutrients. Additionally, some wastewater sources require acidification treatment and/or large quantities of soil amendments to be added (such as when a wastewater may induce a sodic soil condition and large additions of Ca are needed). The nutrient additions, whether directly from the water or as a result of water/soil treatments due to the water characteristics, must be considered as part of the on-going fertilisation plan to maintain a balanced fertilisation programme.

Nitrogen Content. The wastewater treatment facility often must meet a regulatory level for N based on limiting algae and aquatic plant growth in discharge waters. Turfgrass managers should understand how much total N is being added per 100m2 for every 10cm of irrigation water added (10ppm or mg/L of N = .102kg per 100m2 of N for every 10cm of irrigation water applied). And decrease N fertilisation accordingly to avoid over-application of N.

Phosphorus Content. Regulatory P levels for waters discharged from treatment facilities are normally very low since P in water is the most important nutrient controlling algae and aquatic plant growth. As a result, wastewater P contributes only small amount of P to the P fertilisation needs of the turfgrass, but if P levels exceed 0.10-0.40ppm or mg/L of P algae and aquatic plant control will be a challenge.

Ca, Mg, K, Mn, Fe, Cu, Zn, Mo, Ni Levels. It is important to consider the contributions of each of these nutrients to the overall fertilisation needs of the grass and make adjustments as needed. The most common problem is for a particular nutrient to be very high in the water, which may induce nutrient imbalances in the soil and eventually the turf plant – such as high Ca limiting Mg uptake. Sometimes the nature of the irrigation water requires certain amendments to be added to the soil in large quantities, such as when high Na in the water may require high Ca additions to the soil. In these situations, nutrient imbalances can also be induced.

SO4-2 Content. Sulphur, usually as SO_4, is a nutrient that is often high in many wastewaters sources or becomes high as a result of acid treatment when water acidification is necessary. Turfgrass plants only require 1.5-3.0kg elemental S per 100m2 per year as a nutrient. If high SO_4 levels occur in the soil due to high SO_4 in the wastewater, the soluble SO_4 can rapidly revert to reduced S forms when anaerobic conditions occur in the soil – regardless of the source of the anaerobic conditions, such as excess rain, perched water table from a layer in the soil, soil compaction, excess organic matter accumulation, sodic conditions, etc. Reduced S results in formation of FeS and MnS precipitates that cause the black coloration in black layer (3). These precipitates cause more anaerobic conditions. The SO_4 in wastewater can react with Ca in the water to form gypsum ($CaSO_4$), which is much less prone to becoming reduced. If the Ca is not

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sufficient to "scrub" the excess SO4 from the water, light applications of lime can be added to the soil surface, where the SO4 will react with the lime to form gypsum over time (it requires 1kg of lime per 1kg of excess SO4 added). A high level for SO4 would be > 90mg/L SO4 = .304kg per 100m2 elemental S for every 10cm of water added.

Trace Elements. Sometimes trace elements are unusually high in a wastewater source. Thus, an initial analysis of a potential wastewater source may include testing for any expected trace elements. The guidelines for these are based on long-term use of the water assuming that the particular element may accumulate (1).

SALT-RELATED ASSESSMENTS

When salt ions are low, which is common for many wastewaters, the primary problems for wastewater sources would be the nutrient/element content discussed in the previous section. However, when salt ions are high, salt-related problems can be very important and will require appropriate management regimes including – grass selection, possible chemical amendment of water and/or soil, leaching, cultivation programmes, alterations in fertilisation regimes, and other aspects. (1,3). The primary issues to evaluate are summarised as:

Total Salinity. Total soluble salts (TSS) in the irrigation water can cause salt accumulation in the soil and lead to salt-induced drought or specific ion toxicities. TSS is usually measured as Electrical Conductivity (ECw).

Sodium Permeability Hazard. If the wastewater has high Na content, it can create a sodic soil condition. Sodium causes deterioration of soil structure by destroying natural aggregation and dispersing clay/organic colloids that can plug soil pores. The net result is a reduction of macropores (> 0.10mm diameter pores) for water permeability, reduced gas/oxygen exchange, and fewer root channels. No single water parameter can by itself determine sodium permeability hazard, but several parameters are used:

- SARw = Sodium Adsorption Ratio. SARw is used when Na, HCO3, and CO3 are < 100, 120, 15mg/L, respectively.
- AdjSARw by pHc adjustment. Uses Na, Ca, Mg, HCO3, CO3 to adjust the original SARw, or…
- AdjSARw by Cax adjustment (sometimes noted as adjRNa). Also, uses Na, Ca, Mg, HCO3, and CO3 to adjust the original SARw.
- RSC (Residual Sodium Carbonate) which uses in the RSC calculation Ca, Mg, HCO3, and CO3 contents.

In addition to SARw, adjSARw, and RSC values, the following factors are used in determining the severity of sodium permeability hazard:

- Individual water concentrations of ECw, Ca, Mg, Na, HCO3, and CO3. High ECw allows a soil to withstand higher Na without structure loss.
- Clay type. Shrink/swell clays are most prone to structural breakdown.

SPECIFIC TOXIC IONS

Specific ion toxicities are of several types and require guidelines to assess the potential for each type of problems, namely:

- Ions that may accumulate in the soil and cause direct root toxicities – Na, Cl, B.
- Ions (Na, Cl, B) that are taken up by plants and accumulate in the foliage to cause a reduction in physiological activity, colour, and enhance tissue leaf firing or desiccation.
- Direct contact injury to the foliage from the irrigation water, where Na, and Cl are of greatest interest. Trees and shrubs are more sensitive than most grasses.

OTHER CONSIDERATIONS

Turf managers should consider some other factors beyond the constituents in the wastewater, namely:

- Contract stipulations with the wastewater provider should not require wastewater to be accepted by a turf facility when irrigation is not required since this leads to run-off, leaching, is environmentally unsound practice. Since wastewater treatment plants must measure certain parameters on a regular basis, it may be possible to make contractual agreements that result in the treatment facility providing all or most of the irrigation water quality data to the turf facility on a long term basis.
- While Total Suspended Solids are of concern for many non-potable irrigation water sources, it is generally not a concern for treated wastewater since effective treatment for fecal coliform bacteria (indicator organisms for more harmful micro-organisms) requires low levels of suspended solids and is monitored by turbidity measurements at the treatment complex.
- The article on effluent water by Huck et. al. (2000) is suggested for those seeking a detailed discussion of the various costs associated with use of wastewater.

Wastewater characteristics can vary greatly depending on the particular source. However, most wastewaters, treated for application to public sites, are good sources of water for turfgrass irrigation. Obtaining a good water quality test is essential for determining any potential problems or adjustments to management practices that may be needed.

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