IRRIGATING TURFGRASS AND LANDSCAPE PLANTS WITH MUNICIPAL RECYCLED WATER

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Keywords: Sewage water, Reclaimed water, Effluent water, Salinity, Chlorine.

Abstract

Recycled water as a strategy for coping with shortages and/or the rising cost of fresh water maybe a viable means in arid and semi-arid regions and in highly populated metropolitan areas. Public's slow, but increasing, acceptance of use of treated municipal sewage water to irrigate plants, including landscape plants, has made this option a reality. In the future, parks, golf courses, cemeteries, and other venues of non-food, urban horticulture will be better able to compete for reclaimed sewage water than for fresh water. Although ultimate users of recycled water will be dictated by local laws, use of this water on non-food planting leaves more fresh irrigation water for food plants. Factors affecting the decision to use recycled water for landscape irrigation include: human health considerations, seasonal and annual variations in water quality, soil conditions, reclaimed water's dissolved salts and nutrient content, as well as potential water conservation.

1. Introduction

In arid and semi-arid regions and in highly populated metropolitan areas, where water is a limited natural resource, irrigation with recycled water may be a viable means of coping with shortages and/or the rising cost of potable water. Interest in recycled water irrigation continues to increase as more and better quality treated sewage water becomes available for reuse. However, the idea of using treated sewage water to irrigate plants, even non-food crops such as turf and other landscape plants, is new and probably a bit unsettling to most people.

The public is currently unwilling to accept the return of recycled effluent water to municipal water systems for drinking, cooking, and bathing. In recent years, however large quantities of recycled water have been used to irrigate parks, roadsides, landscapes, golf courses, cemeteries, athletic fields, and other landscape sites.

Although there is not much competition for use of recycled water at this time, such competition is likely in the near future. Nevertheless, parks, golf courses, cemeteries, sports fields, industrial parks, green belts and other turfed and landscaped sites will clearly be in a better position to compete for reclaimed water than for fresh water. Although the ultimate users of effluent water will no doubt be circumscribed by local laws and regulations, several arguments favor use of this water on turf, landscape, and other non-food plantings as opposed to food plants.

First, turfgrasses in particular can absorb relatively large amounts of nitrogen and other nutrients often found in higher quantities in recycled water than in fresh water. This characteristic may greatly decrease the chances of ground-water contamination by recycled irrigation water.

Second, recycled water is produced continuously, and any use of it, therefore, also needs to be continuous. A turfgrass and/or landscape "crop" is continuous (i.e., uninterrupted by cultivation, seeding, or harvest, all of which characterize food crops

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and require stopping irrigation for considerable periods.)

Third, most expanses of irrigated turf are located adjacent to cities where recycled water is produced, thus minimizing transportation costs.

And finally, soil-related chemical problems that might develop due to the use of recycled water will have a smaller social and economic impact if they develop where turf and landscape plants are cultivated than if they develop where food crops are grown.

For all of the above reasons, turfgrasses specially may be the best plants for recycled water irrigation. However, some turfgrasses are better adapted to its use than others. Pronounced differences exist among turfgrass species in tolerance to both individual salts and total salinity necessitating evaluation of each species with regard to specific water and soil salinity characteristics. Table 1 is a general guide to individual turfgrass salt tolerance. (Harivandi *et al*., *1992).*

2. What Is Recycled Water?

"Recycled water" refers to any water, which has undergone one cycle of use and then received significant treatment, at a sewage treatment plant, to be made suitable for limited reuse. Several other terms are also used for recycled water, among them: reclaimed water wastewater, effluent water, treated effluent water, and treated sewage water.

Recycled water may be primary, secondary, or advanced (tertiary) treated municipal or industrial wastewater. Primary treatment is generally a screening or settling process that removes organic and inorganic solids from the wastewater. Secondary treatment is a biological process in which complex organic matter is broken down to less complex organic material, then metabolized by simple organisms which are later removed from the wastewater. Advanced wastewater treatment consists of processes that are similar to potable water treatment, such as chemical coagulation and floculation, sedimentation, filtration, or adsorption of compounds by a bed of activated charcoal. Advanced treatment is often referred to as "tertiary treatment". Regardless of the degree of treatment, all recycled waters are heavily disinfected by chlorination, or other methods before discharge from the treatment plant. (Harivandi, 1994).

3. Health Considerations

The biological composition of recycled water is of concern because of potential presence of pathogenic bacteria and viruses. Properly operated secondary and advanced treatment plants can reduce pathogen concentrations significantly. (Asano, *et al.*, 1984). However, it is difficult to insure complete, continuous elimination of pathogens, and the potential for disease transmission through reuse of treated effluent water, although highly improbable, remains a concern.

Although some risk of human exposure to pathogens exists in almost every waste-water reclamation operation, the health concern in each situation is proportional to the degree of human contact with the water, and the adequacy and reliability of the waste-water treatment processes. Effluent waters are not generally released for irrigation without prior approval of public health authorities.

Regulations concerning the use of recycled water vary among countries and localities. A basic objective of these regulations is assuring human health protection without unnecessarily discouraging wastewater reclamation; the degree of treatment required increases with the likelihood of human exposure to the wastewater. Therefore, most regulations specify different reuse standards for wastewater irrigation, impoundments, and groundwater recharge. They also differentiate between types of landscape irrigation based on public access to the use area and thus expected public exposure to the recycled water. Wastewater that has received secondary treatment and been disinfected to a level of 23 total coliforms per 100 mL, for example, may contain both bacterial and viral pathogens, so direct contact with the water should be avoided.

However, assuming that irrigation occurs during periods when the public is excluded from the use area, and that there is sufficient time for the grounds to dry before use, direct contact with the recycled water is avoided. Health risks may then arise from indirect contact only – with grass, shrubs, and objects that have been previously wetted with recycled water. Even such indirect contact is relatively infrequent in places like golf courses, freeway landscapes, and cemeteries, and probably does not warrant the expense of requiring recycled irrigation water used in these areas to be free of all infectious organisms.

On the other hand, parks, playgrounds, schoolyards, and similar areas are more intensively used, and children may be especially susceptible to some of the pathogens typically found in sewage. Therefore, the quality and treatment requirements for this type of landscape irrigation are identical to those required for the spray irrigation of food crops.

The possibility of disease transmission, by aerosols or wind-blown spray from landscape irrigation, although slight, must also be considered, because of the proliferation of reuse projects in urban settings or adjacent to populated areas. The degree of potential hazard depends on several factors, including degree of wastewater treatment, extent of aerosol or water-droplet travel, proximity to populated areas or areas accessible to the public, prevailing climatic conditions, and design of the irrigation system.

4. Constancy of Supply

Most contracts for recycled water require that a specific volume be accepted each day, regardless of weather conditions. This may cause problems since while the water supply is continuous, plant's need for water varies considerably and depends on weather and climate. Therefore, storage capability is a common feature of systems using recycled water. Lakes, ponds, lagoons and underground storage tanks may all be used to store recycled water.

In most cases, the storage facility is a critical link between treatment plant and irrigation system and is needed (a) to equalize daily variations in flow from the treatment plant, and to store excess water when recycled water flow exceeds irrigation demands (as in winter); and (b) to meet peak irrigation demands in excess of the average daily recycled water flow. Storage also insures against the possibility of unsuitable recycled water entering an irrigation system by providing additional time to resolve any temporary water quality problems belatedly discovered by the treatment plant. Suspended solids, nitrogen, and microorganisms may also be reduced during storage. On the negative side, however, since most recycled waters contain large quantities of nutrients, weed and algae growth in open storage facilities (e.g. ponds and lakes) may require extra maintenance compared to lakes containing only fresh water.

5. Soil Related Issues

In almost all cases, although local treatment and quality requirements for irrigation use are intended to insure an adequate degree of health protection from disease transmission, they do not address potential effects of recycled water on either plants or soil. Soils vary widely in the physical and chemical properties relevant to successful recycled water irrigation of turfgrass and other landscape plants. Cation exchange capacity, infiltration rate, percolation rate, and water-holding capacity are among the more important soil factors to consider before applying recycled water. Coarse-textured soils such as sandy loams are best for the use of recycled water; heavier soils are acceptable as long as changes in soil chemical properties are evaluated regularly.

The soil's water-holding capacity also determines its suitability for recycled water irrigation. Frequent application of recycled water to soils with high water- holding capacity, such as clay soils, will contribute significantly to the accumulation of salts and

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heavy metals.

Shallow soils overlaying rock, hard pan, or clay pan often have poor water percolation and drainage. The corresponding perched water tables also promote accumulation of salts and heavy metals.

6. Irrigation System Factors

To avoid of potential clogging of sprinkler nozzles, an effective filtration system is needed to remove any suspended matter from the recycled water before it enters the irrigation system. This is particularly important if recycled water is stored in a lake or pond, (where the probability of algae growth is high) before irrigation. Also, because both harmful (salts) and beneficial (nutrients) chemical substances may be applied with recycled irrigation water, every effort should be made to distribute water uniformly.

7. Nutrient Content

Since recycled water can be high in nutrients, the nutrient value of recycled water may be an important economic consideration. (Wescot and Ayers, 1984; Asano *et al.*, 1984). Nitrogen, phosphorus and potassium, all of which are essential to turfgrass growth, are the primary nutrients present in most recycled waters. Even if the quantities of nutrients in a given recycled water are small, they are efficiently used by turfgrass because they are applied on a frequent, regular basis. In most cases, turf and other landscape plants obtain all the phosphorus and potassium they need, and a large part of the nitrogen, from recycled water. Sufficient micronutrients are also supplied by most recycled waters.

8. Recycled Water Chemical Composition

As noted above, the chemical constituents of recycled water are important in turf and landscape irrigation. The composition of untreated and treated wastewater depends on the composition of the municipal water supply, as well as on the number and type of commercial and industrial establishments and the nature of the residential communities contributing to the water supply. Consequently, the composition of treated effluent water often varies widely among communities.

As long as the wastewater has gone through a secondary and/or advanced treatment process, it is probably suitable for turfgrass and landscape irrigation. Instances where treated municipal wastewater quality is poor enough to preclude its use for irrigation are rare.

Nevertheless, because effluent waters do contain impurities, careful consideration must be given to each situation to evaluate possible long-term effects on soils and plants. The most common water quality problems associated with the use of recycled water are summarized below (Wescot and Ayers, 1984; Richards, 1954; Pound and Crites, 1973).

8.1. Salinity

Salinity problems occur when the total quantity of soluble salts in the plant root zone is too high. Most recycled waters contain appreciable amounts of salts, and could conceivably lead to soil salt levels harmful to plants, especially in heavy soils.

Generally, potable water picks up large quantities of inorganic salts in one cycle of use. Depending on the initial salt content of the water, this could make the recycled water unsuitable for turfgrass and landscape irrigation. For example, if the original water contained 600 mg L^{-1} salt, and during the first cycle of use another 300 mg L^{-1} salt was added, the resulting effluent would contain 900 mg L^{-1}, an amount considered potentially hazardous to turf and landscape plants, especially on heavy clay soils.

8.2. Permeability

Permeability problems may occur if effluent water contains high levels of sodium. Relative permeability hazard is often expressed as SAR (Sodium Adsorption Ratio), the ratio of sodium to calcium and magnesium. A high ratio – above 9 – indicates potential permeability problems.

Carbonate and bicarbonate content can also affect soil permeability and must be evaluated along with the calcium, magnesium, and sodium content of both soil and recycled water.

8.3. Toxic elements

Recycled waters usually contain a wide variety of elements in small concentrations. Problems can occur if certain elements accumulate in the soil to levels toxic to turfgrass and other plants. Toxicities may be caused by accumulation of boron, chloride, and sodium. Boron is added to water through the use of soaps and detergents, and its concentration can vary from 0.5 to 1 mg L^{-1}. Although this range by itself is not toxic to most plants, levels may increase on heavy soils and present problems, especially for trees and shrubs. Turfgrasses are usually much more tolerant of boron than other plants as long as they are mowed and the clippings are removed regularly. (Oertli *et al.*,, 1961).

Chloride is not particularly toxic to turf, but most trees and shrubs are quite sensitive to a water chloride content in excess of 355 mg L^{-1}.

In addition to its negative effects on soil permeability, excessive amounts of sodium can be directly toxic to some turfgrass species and most ornamental plants. The toxic effects of sodium, as well as those of chloride, are more severe where recycled irrigation water is directly applied to plant foliage.

8.4. Chlorine

Disinfectants used to reclaim sewage water are usually to blame when chlorine toxicity occurs. When reclaimed water moves immediately from treatment to sprinkler, it may carry large amounts of chlorine onto leaf surfaces and cause chlorine toxicity. Free chlorine is very unstable in water and will dissipate rapidly if the water is stored for even a short period between treatment and application to plants. Residual chlorine is only of concern at levels greater than 5 mg L^{-1} (Asano *et al.*, 1984).

9. Conclusions

Using recycled water to irrigate landscape plants, particularly turfgrass, is an increasingly attractive alternative to the often high-priced, limited supply of fresh water available for landscape irrigation. This is especially true in areas where direct public exposure to the recycled water is minimal. Depending on the quality of the water, irrigation with recycled water may be more desirable for some plant species than for other.

Many turfgrasses are particularly well-suited to this type of irrigation due to both inherent physiological characteristics and the conditions under which they are cultivated (i.e., with frequent mowings and continous, year-round maintenance). They are one of the few crops able to survive some of the deleterious effects (such as high concentrations of boron) of recycled water while actually profiting from others (e.g. high concentrations of nitrogen and potassium).

Recycled water provides an additional water source where the supply of fresh water is limited. This factor is of particular importance in arid countries and in all highly populated areas of the world, where water is becoming a more limited natural resource.

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Tables

1. Turfgrass species tolerate varying levels of soil salinity, which in turn is strongly influenced by the salinity level of recycled irrigation water. Grasses listed here are grouped by their tolerance to soil salinity (Harivandi *et al.*, 1992).

Sensitive < 3 dSm^{-1}	**Moderately sensitive (3 to 6 dSm^{-1})**	**Moderately tolerant (6 to 10 dSm^{-1})**	**Tolerant > 10 dSm^{-1}**
Annual bluegrassess (*Poa Annua*)	Annual ryegrass (*Lolium moltiflorum*)	Perennial ryegrass (*Lolium perenne*)	Alkaligrasses (*Puccinellia spp.*)
Colonial bentgrass (*Agrostis tenuis*)	Creeping bentgrass (*Agrostis palustris*)	Tall fescue (*Festuca arundinacea*)	Bermudagrasses (*Cynodon spp.*)
Kentucky bluegrass (*Poa pratensis*)	Bahiagrass (*Pasplum notatum*)	Buffalograss (*Buchloe dactyloide*)	Seashore paspalum (*Paspalum vaginatum*)
Rough bluegrass (*poa trivialis*)	Chewings fescue (*Festuca rubra spp. Commutata*)	Zoysiagrasses (*Zoyasia spp.*)	St. Augustinegrass (*Stenotaphurm secundatum*)
Centipedegrass (*Eremochloa ophiuroides*)	Creeping red fescue (*Festuca rubra spp. Rubra*)	Creping bentgrass cv. Seaside (*Agrostis palustris*)	
	Hard fescue (*Festuca longifolia*)	Fairway wheatgrass (*Agropyron cristatum*)	
		Slender creeping red fescue cv. Dawson (*Festuca rubra spp. Trichophylla*)	
		Westeren wheatgrass (*Agropyron smithii*)	
		Bluegrama (*Bouteloua gracilis*)	

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