Using Effluent Water On Your Golf Course

by DR. DAVID KOPEC, DR. CHARLES MANCINO, and DOUGLAS NELSON
University of Arizona, Tucson, Arizona

YOU MIGHT CALL IT a recycler's nightmare. Every day, 365 days a year, hundreds of millions of gallons of useable treated water is dumped needlessly into the ground, rivers, and oceans of the world. Is this truly necessary, or is there an alternative method of disposal to allow the recapture of some of this water and put it through a natural filter? Actually, there is! Parks, golf courses, sports fields, and certain agricultural crops all can use effluent water for irrigation.

In addition to preventing needless dumping, a useable effluent water supply has several other advantages. These include (1) guaranteed availability, even during periods of drought, (2) a nutrient content that potentially can lessen dependence on manufactured fertilizers, (3) the freeing of limited supplies of potable water for other, more essential uses, and (4) income, from the sale of effluent water to agricultural users, to pay for the construction of public sewage treatment plants.

Before running to the faucet and turning on an effluent water supply, however, there are several points that should be considered. To begin with, a thorough understanding of effluent water and how it is produced is essential.

What is Effluent?

The source of most effluent water supplies comes from municipal sewage that is approximately 99.9% water (effluent) and

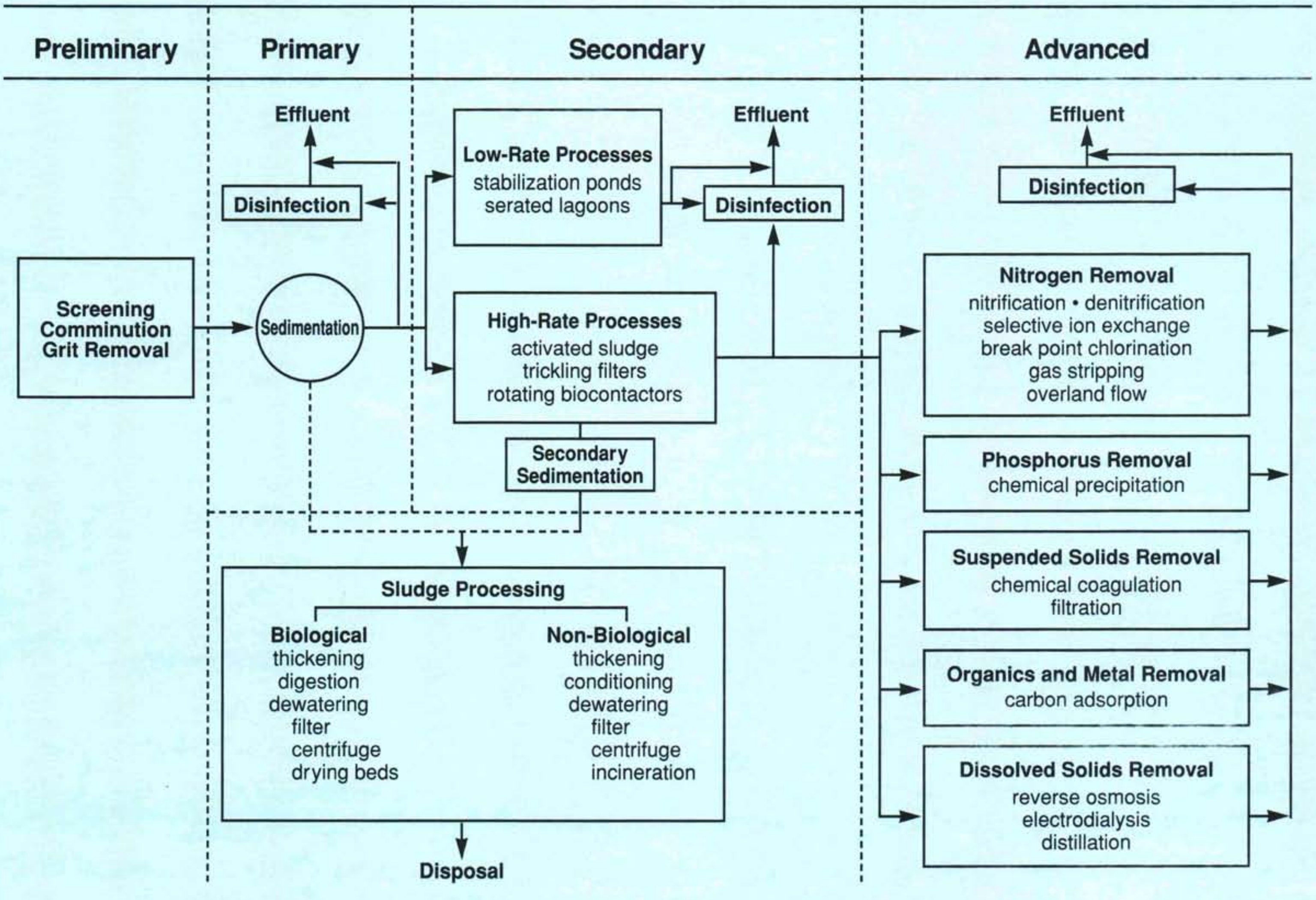
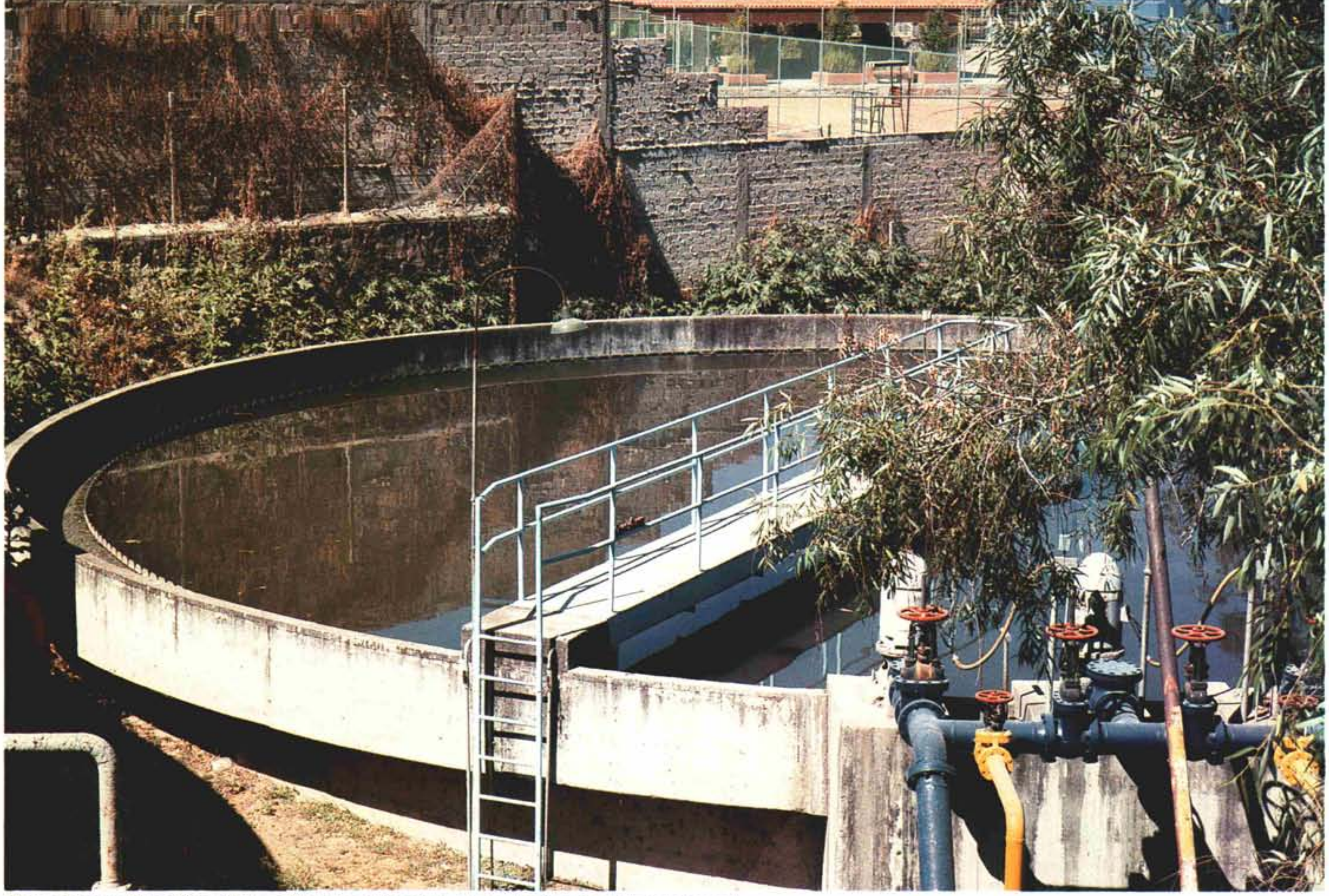


Figure 1 — Generalized Flow Sheet for Wastewater Treatment

Source: Asano, T., R. G. Smith, and G. Tschobanoglous, 1984



To produce usable effluent for golf course irrigation, the water is screened and treated.

.06% solids (sludge). To produce useable effluent for golf course irrigation, treatment plants process the raw sewage in several successive stages (Figure 1).

The first stage of the process is known as primary treatment. This involves screening the raw sewage for large debris and placing it in settlement ponds. The solid particles either sink or float and are removed. Primary effluent contains no more than 50% solids. Following primary treatment, the resulting effluent usually has a very foul odor and contains numerous harmful pathogens. Effluent water at this stage is not yet suitable for irrigation.

The next stage of the process is known as secondary treatment. This stage involves removing more than 90% of the original solids via microbial digestion by pumping the effluent through large cylindrical vats containing bacterial colonies. Following solid removal, the effluent usually is chlorinated, so that the coliform bacterial count is less than 23 per 100 milliliters of water (Table 1). Because secondary treated effluent has been chlorinated to reduce human health risk and is virtually solid-free, it commonly is used for irrigation of turf and several non-edible crops.

Even though secondary effluent can be used for irrigation, many treatment plants continue the process with a final stage known as tertiary treatment. Tertiary treatment involves the removal of non-biodegradable organic pollutants and a significant percentage of nutrients, such as nitrogen and phosphorus. Tertiary effluent can be described as having no foul odor and a coliform bacterial count of less than 2.2 per milliliter, and can be used safely for most purposes.

Understanding what effluent water is and what it is not allows us to address concerns of the golfing public and to develop maintenance practices to compensate for its use on the golf course.

Table 1
Water Treatment and Quality Criteria for Irrigation in California

Treatment Level	Coliform Limits Per 100 Milliliters	Type of Use
Primary		Surface irrigation of orchards and vineyards Fodder, fiber, and seed crops
Oxidation and disinfection	≤ 23	Pasture for milking animals Landscape impoundments Landscape irrigation (golf courses, cemeteries, etc.)
	≤ 2.2	Surface irrigation of food crops (no contact between water and edible portion of crop)
Oxidation, coagulation, clarification, filtration, and disinfection	≤ 2.2	Spray irrigation of food crops Landscape irrigation (parks, playgrounds, etc.)

Source: California Department of Health Services, 1978

Table 2
Constituents of Concern in Wastewater Treatment and Irrigation with Effluent Water

Constituent	Measured Parameters	Reason for Concern
Suspended solids	Suspended solids, including volatile and fixed solids	Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment. Excessive amounts of suspended solids cause plugging in irrigation systems.
Biodegradable organics	Biochemical oxygen demand, chemical oxygen demand	Composed principally of proteins, carbohydrates, and fats. If discharged to the environment, their biological decomposition can lead to the depletion of dissolved oxygen in receiving waters and to the development of septic conditions.
Pathogens	Indicator organisms, total and fecal coliform bacteria	Communicable diseases can be transmitted by the pathogens in wastewater: bacteria, viruses, parasites.
Nutrients	Nitrogen Phosphorus Potassium	Nitrogen, phosphorus, and potassium are essential nutrients for plant growth, and their presence normally enhances the value of the water for irrigation. When discharged to the aquatic environment, nitrogen and phosphorus can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, nitrogen can also lead to the pollution of groundwater.
Stable (refractory organics)	Specific compounds (e.g., phenols, pesticides, chlorinated hydrocarbons)	These organics tend to resist conventional methods of wastewater treatment. Some organic compounds are toxic in the environment, and their presence may limit the suitability of the wastewater for irrigation.
Hydrogen ion activity	pH	The pH of wastewater affects metal solubility as well as alkalinity of soils. Normal range in municipal wastewater is pH = 6.5-8.5, but industrial waste can alter pH significantly.
Heavy metals	Specific elements (e.g., Cd, Zn, Ni, Hg)	Some heavy metals accumulate in the environment and are toxic to plants and animals. Their presence may limit the suitability of the wastewater for irrigation.
Dissolved inorganics	Total dissolved solids, electrical conductivity, specific elements (e.g., Na, Ca, Mg, Cl, B)	Excessive salinity may damage some crops. Specific ions such as chloride, sodium, boron are toxic to some crops. Sodium may pose soil permeability problems.
Residual chlorine	Free and combined	Excessive amount of free available chlorine (0.05 mg/l) may cause leaf-tip burn and damage some sensitive crops. However, most chlorine in reclaimed wastewater is in a combined form, which does not cause crop damage. Some concerns are expressed as to the toxic effects of chlorinated organics in regard to groundwater contamination.

Source: Asano, T., R. G. Smith, and G. Tschobanoglous, 1984

Human Considerations

The most common question raised by the golfing public concerns that of human health (Table 2). Although effluent water is derived from municipal sewage, people should generally feel safe if exposed to effluent because it has been chlorinated. In fact, many public health officials concede that some tertiary effluent supplies could be used for swimming, although at this point in time adequate supplies of potable water are still available.

Despite the low human health risk involved with using effluent water, legislation nonetheless has been written to reduce exposure to an absolute minimum. This legislation consists primarily of restricting the use of the irrigation system to non-daylight hours, when golfers are absent from the course, and posting the course with signs, such as *"Warning: Course Irrigated With Reclaimed Water."* In some cases, to comply with this legislation requires the installation of an automatic irrigation system that can deliver the volume of effluent water necessary to irrigate the course within a nightly eight-hour irrigation cycle.

In the environmental '90s, some concern also is being raised by the general public as to possible adverse side effects on wildlife. Again, due to chlorination, irrigation with effluent water poses little risk to wildlife. Furthermore, the use of effluent water on golf courses prevents its dumping in pristine public waterways, where the nutrient content would promote damaging algae growth.

Chemical Interactions

The first step in developing maintenance practices to accommodate effluent water usage is to have a sample analyzed to determine the following parameters:

- Salt concentration.
- Sodium hazard.
- Bicarbonate concentration.
- Toxic ion concentration.
- pH.

Salt Concentration — Effluent water generally contains a significant amount of several salts that are combinations of sodium

(Na), chlorine (Cl), magnesium (Mg), calcium (Ca), sulfate (SO_4), and bicarbonates (HCO_3). After irrigation with effluent, these salts accumulate in the soil and attract pure water molecules, preventing some of the water from being absorbed by the turfgrass plants. As a result, less "free" water is available for turfgrass uptake and symptoms of drought stress begin to occur.

Sodium Hazard — Sodium hazard indicates the relative amount of sodium (Na) in relation to calcium (Ca) and magnesium (Mg). A high amount of sodium in effluent water is undesirable from a water and soil standpoint. In addition to being a component of salt stress, sodium (Na) accumulation eventually will result in displacement of calcium (Ca) and magnesium (Mg) on the exchange sites of soil particles. This in turn inhibits the ability of the soil to aggregate and form peds necessary to maintain good soil structure.

Bicarbonate Concentration — Bicarbonate (HCO_3) concentration is important because of its ability to form precipitates of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). These precipitates "steal" calcium and magnesium from the soil particle exchange sites, and in turn can be replaced by sodium. Of lesser importance is that excess bicarbonate can lead to an increase in soil pH.

Toxic Ion Concentration — High concentrations of specific ions, such as chlorine and boron, can cause damage as they accumulate in plant tissue. Fortunately, turfgrasses are relatively tolerant of several toxic ions. These ions tend to accumulate in the leaf tip and are removed during mowing. Many ornamental trees and shrubs are not as fortunate, however, and can experience disfiguring leaf burns. The type and amount of toxic ions found in effluent is a function of where the raw sewage emanates from. Generally speaking, most municipal effluent does not contain high toxic ion concentrations, whereas industrial and mining effluent does.

pH — The pH (negative logarithm of the hydrogen ion concentration) of effluent water serves as an indication that there may be some type of ion imbalance in the water. In general, it is held that the pH of the water itself is not a problem, as most soils have a great resistance to pH alteration.

What Next?

With an understanding of the chemical characteristics of effluent water, developing maintenance practices that compensate for any negative attributes is a relatively simple matter. To begin with, the highest management priority is determining the water's total salt concentration. As mentioned previously, dissolved salts can quickly accumulate in the soil and inhibit "free" moisture/nutrient uptake.

To avoid such an occurrence, periodic heavy irrigation cycles must be programmed to saturate the soil and leach the salts below the root zone. To accommodate salt leaching, the importance of good subsurface drainage cannot be overstated. This point is especially important in regard to putting greens, where excessively wet conditions would make the soil more susceptible to excessive compaction from concentrated foot traffic.

Another high priority is the sodium hazard, or the relative amount of sodium in comparison to calcium and magnesium. If the sodium hazard is high, the sodium ions will accumulate on the soil exchange sites and cause degradation of the soil structure. As a counterbalance, additional calcium should be added to the soil. In a majority of cases, this can be done by applying calcium sulfate (gypsum) in either a granular or liquid formulation.

In cases where the soil has a high pH and excess free calcium carbonate, however, sulfur should be applied. As the sulfur breaks down, it dissolves the natural calcium deposits and increases the availability of minor nutrients by lowering the pH.

As a potential benefit, many effluent water supplies contain substantial amounts of nitrogen, phosphorus, and potassium (Table 3). However, due to daily and seasonal nutrient fluctuations, it is not possible to calculate the exact amount of these nutrients that will be deposited on the turf so that it can be subtracted from the annual fertilization program. Therefore, monitoring of both turf performance and soil test data should be done to make the necessary adjustments.

Although nutrient content is a potential benefit, toxic ions are another matter. If present, some toxic ions can lead to the deterioration of the turf and the surrounding landscape. Since the removal of toxic ions from an effluent supply would not be economically feasible in most cases, and they cannot be effectively leached through the soil, blending of the effluent with other water sources is likely to be the only real solution. For example, the concentration of boron could be reduced to a nontoxic level by blending an effluent water supply with a well water supply.

Though not directly toxic to plants, high bicarbonate levels in effluent water can contribute to sodium buildup in the soil by reacting with calcium and magnesium. To prevent this reaction, acid injection (the addition of acid to the effluent water) sometimes is used to lower the pH and nullify the bicarbonate ion. To determine the potential benefits of acid injection, water samples can be submitted for special testing.

Conclusion

As an alternative to potable water use, effluent water can in fact be a logical, safe, and economical choice for golf course and sports turf irrigation. Furthermore, it offers an environmentally responsible choice to the wholesale dumping of treated water into existing waterways. Turning on the faucet simply requires understanding both what effluent water is and what it is not!

Table 3
Potential Fertilizer Value of Irvine Ranch Water District Reclaimed Water (Per Acre-Foot)

Nutrients	Concentration mg/l	Pounds/ac.-ft.	Commercial* Value $/ac.-ft.
Nitrogen (N)	23.0	62.6	$11.27
Phosphorus (P)	2.2	6.0	2.82
Potassium (K)	13.9	38.1	6.10
Total Potential Fertilizer Value			$20.19

*Commercial value based on average fertilizer prices for the summer of 1980: N = 18¢/lb., P = 47¢/lb., K = 16¢/lb.
Source: Asano, T., 1981

REFERENCES

Asano, T. (Proj. Dir.). 1981. Evaluation of agricultural irrigation projects using reclaimed water. Agreement 8-179-215-2. Office of Water Recycling. California State Water Resources Control Board. Sacramento, CA.

Asano, T., R. G. Smith and G. Tschobanoglous. 1984. *in* Pettygrove, G. S., and T. Asano (eds.). 1984. Irrigation with Reclaimed Municipal Wastewater — A Guidance Manual. Report No. 84-1 California State Water Resources Control Board. Sacramento, CA.

California Department of Health Services. 1978. Wastewater reclamation criteria. California Administrative Code.