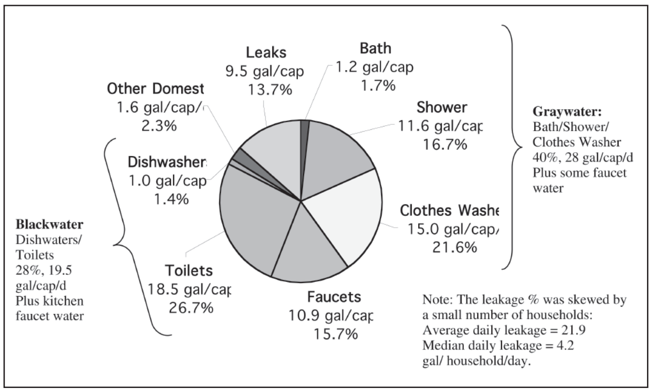
Long-Term Effects of Landscape Irrigation Using Household Graywater

This report brings together current state of knowledge on potential long-term impacts of landscape irrigation with household graywater and identifies data gaps needing to be addressed. The review found that there may be significant benefits attained from use of household graywater, in particular, for water conservation and reuse. For example, household demands for potable water could be reduced by 30-50%, and household graywater could supply a significant amount of the irrigation for a typical yard.



Average Indoor Residential Water Usage for 12 North American Cities.
Adapted from Residential End Uses of Water, by permission. Copyright ©1999, American Water Works Association and Awwa Research Foundation (AwwaRF).

However, there is much that is not known about the potential adverse effects of graywater use and more research is needed. In particular, there are two areas of concern with the practice: the potential threat to human health and the potential long-term impact of graywater on plants, soil chemistry, and microbiology.

Graywater Quantity and Systems

In this report, graywater is defined as wastewater that originates from residential clothes washers, bathtubs, showers, and sinks. Toilets, kitchen sinks, and dishwashers are not included due to the high organic content leading to oxygen depletion and increased microbial activity of the graywater.

Graywater constitutes about 50% of the total wastewater generated (69 gallons/person/day) within a household. Given an average household population of 2.6 persons in the U.S., there are approximately 90 gallons of graywater per day per household available for outside use. This supply is not enough to irrigate an entire yard landscaped in bedding plants and bluegrass, but a homeowner with a 2,500 ft^2 house on a 1/4-acre lot could irrigate about half of the yard with graywater if xeriscaping is used.

To install an efficient graywater irrigation system it's necessary to know the water requirements of the plants to be irrigated, and to have a collection and storage system that will deliver graywater at the appropriate time and in the appropriate amount to the landscape. Currently, guidance on application rates is lacking. While some sophisticated graywater systems are available for storage, treatment, and delivery of graywater, guidance is lacking for the homeowner to design a proper system in terms the size of storage tank required, and the required pump capacity where a gravity system is not feasible.

Graywater Chemistry Issues

Graywater contains a complex mixture of chemicals used in a variety of house-

BENEFITS

- Synthesizes current state of the knowledge on graywater reuse for landscape irrigation at the household level
- Identifies information gaps for future research on the long-term use of graywater for irrigation of residential landscapes, particularly as it relates to human health, landscape plants, and/or the environment

RELATED PRODUCTS

Management Practices for Nonpotable Water Reuse (97IRM6)

Research Needs to Optimize Wastewater Resource Utilization (98CTS1)

Water Reuse: Understanding Public Perception and Participation (00PUM1)

Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management (04DEC2)

Microbial Risk Assessment Interface Tool (04HHE3)

RELATED ONGOING RESEARCH

Long-Term Effects of Landscape Irrigation Using Household Graywater, Phase 2 (06-CTS-1CO)

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hold products. These chemicals can be categorized according to their function, such as surfactants, detergents, bleaches, dyes, enzymes, fragrances, flavorings, preservatives, builders, etc. A survey by the National Institute of Medicine and the National Institute of Health reported that household products contain over 2,500 chemicals in 5,000 products (National Institute of Health, 2004). It's assumed that many, if not most, of these chemicals occur in graywater. These chemicals can change the bulk chemical characteristics of the water such as pH, suspended solids, biological oxygen demand, and conductivity.

The literature reveals that a number of constituents in typical graywater are known to be potentially harmful to plants singly or in combination with other chemicals in graywater. But it remains to be documented whether or not these constituents will accumulate in soil in sufficient quantities to harm plants or perhaps be transported below the root zone, possibly to the groundwater, during the rainy season. Although there are a number of graywater systems that have been in operation for some years with no obvious detriment to vegetation, the scientific documentation is lacking. No published studies were found that examined the changes in soil chemistry as a result of irrigation with graywater.

Effects on Landscape Plants

Information on the effects of graywater irrigation on landscape plants is scarce. In Arizona, a two-year study on landscape plants irrigated with graywater in residential areas revealed that, except for a slight increase in boron, no salts had accumulated in either the plants or the surrounding soil (NSFC, 2002). In California, a graywater pilot project was conducted Los Angeles in the early 1990s (City of Los Angeles, 1992). This study found that the Soil Adsorption Ratio (SAR) and Na+ increased over the course of the study; however, negative effects on plant growth and quality of landscape plants were not observed. The authors pointed out that any harmful effects might take a number of years to manifest themselves.

Plant resistance levels have been mainly extrapolated from other salinity experiments or from experiments with recycled wastewater used for irrigation. These studies found that most deciduous trees are more tolerant to salt than evergreens because they lose their leaves each fall, thereby preventing a great degree of build up of harmful constituents from season to season.

Effects on Soil Microbiology

Information is lacking on the short-term and long-term effects of graywater irrigation on indigenous soil microorganisms. Impacts are difficult to predict due to the ever-changing and heterogeneous nature of graywater chemical constituents. Organic matter and nutrients in graywater may stimulate microbial growth and degradation activities in the soil in the short term, but the long-term impacts of graywater irrigation might be detrimental to soil microorganisms and their important ecosystem functions due to the buildup of chemical constituents, including salts and potential toxins. Another possible complication is that graywater storage systems can harbor diverse, microbial biofilm communities that are capable of degrading some constituents of graywater, including surfactants (a positive effect), but may also cause physical clogging of the flow regulators in drip irrigation systems, and possible soil pore spaces.

On the positive side, most studies that have examined the impacts of wastewater effluent have shown a benefit to soil microbial communities due to the inputs of organic matter and nutrients.

Public Health Issues

It is well established that the levels of fecal coliform in graywater exceed allowable criteria set by regulatory agencies for discharge of wastewater, and for natural waters subject to body contact. But there is controversy regarding whether indicator organism counts are an accurate indicator of actual health threat posed to the homeowner who comes into direct contact with graywater. Therefore, a high graywater fecal coliform count may not indicate the same level of pathogen exposure risk as the same fecal coliform count found in treated wastewater. Even so, many states that permit graywater use require a subsurface irrigation system to reduce human exposure to pathogens, but this requirement detracts significantly from its attractiveness to the average homeowner. Drip irrigation would be much more attractive, but before it is recommended it is important to determine how well the fecal bacteria survive in the surface layer of the soil.

CONTRACTOR

Larry A. Roesner, Ph.D., P.E.
Yaling Qian, Ph.D.
Colorado State University

PROJECT TEAM

Mary Stromberger, Ph.D.
Stephen Klein, Ph.D.
Melanie Criswell
Ramadan Alkhatib
Colorado State University

PROJECT SUBCOMMITTEE

Drew C. McAvoy, Ph.D., Chair
Procter & Gamble Company

Victoria Cross
City of Los Angeles, Department of Water and Power

Alvaro J. DeCarvalho
Consultant

Daniel Edwards, Ph.D.
Alticor, Inc.

Herschel A. Elliott, Ph.D., P.E.
Penn State University

Val Little
University of Arizona

William Von Wagoner
City of Los Angeles

STEERING COMMITTEE

Kathleen Stanton
The Soap and Detergent Association

COLLABORATORS

The Soap and Detergent Association

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