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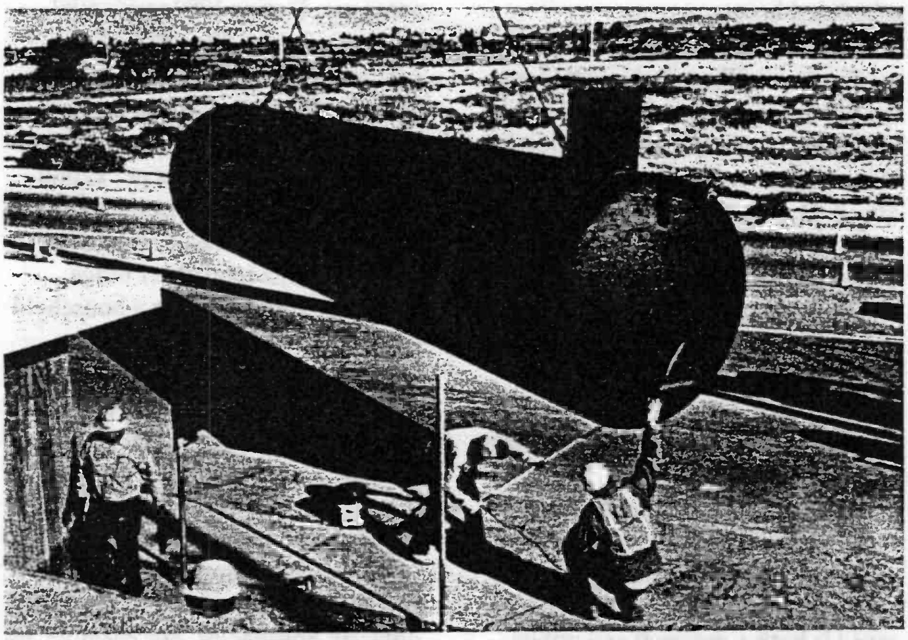
Home Use of Graywater, Rainwater Conserves Water—and May Save Money

by Joe Gelt

Conserve, reuse and augment summarize Arizona's strategy to meet new water needs and reduce its reliance on dwindling groundwater reserves. Of the strategic trio, water conservation is an approach utilized by the entire hierarchy of water users, from industrial and agricultural users to individual households using water to cook, grow trees and shrubs, and wash the dog.

Reuse and augment are a different story. These often require complex projects, usually undertaken by engineers and scientists to benefit high-demand water providers and users who have the financial resources to pay—or the political clout to prod government to pay. For example, building a reclaimed water distribution system is part of a reuse strategy. The Central Arizona Project and weather modification are oft-mentioned augmentation efforts. Such projects are beyond the direct participation and control of individual households.



A tank to store graywater is installed at Casa del Agua, Tucson's water conservation house. The tank is about six and one half feet in diameter, 30 feet long, and holds about 7,000 gallons. (Photo: Rocky Brittain)

Reuse and augmentation options directly available to the homeowner generally are limited to graywater use and rainwater harvesting. Not all households, however, can take advantage of these options. Such variables as type and location of residence, financial resources, and legal restrictions and prohibitions determine whether a household is able to make use of these strategies.

(Further drawing out the parallel between government and domestic reuse and augmentation activities, one might argue that the purchase of bottled water also be viewed as a strategy to augment a household's water supply. It could be seen as water marketing in miniature. This, however, would be straining the comparison. Besides, bottled water is more a water quality issue than a water supply issue.)

Casa del Agua and Desert House

Casa del Agua and Desert House are experiments set up to test and evaluate various water saving devices and strategies includ-

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ing graywater use and rainwater harvesting in residential facilities. Casa del Agua is a Tucson residence that was retrofitted with water-conserving fixtures and reuse technologies and landscaped with drought tolerant plants. As an occupied domestic residence, Casa del Agua provides a setting to research and test domestic water use and conservation strategies. Casa del Agua also is an educational project, open to the public during scheduled hours.

Constructed in the Desert Botanical Garden in Phoenix, Desert House is a water- and energy-efficient exhibit consisting of a house and an adjoining information center. Dedicated on May 8, Desert House also will be home to a family. By living with and using the installed water-and-energy efficient technologies, the family will test and demonstrate their effectiveness. Desert House includes graywater use and rainwater harvesting systems. A public information center is part of the facility.

Both projects emphasize that saving water is not just good public policy, but also wise household management. In other words, water saved is both a personal and public good. The projects are meant to demonstrate that graywater use and rainwater harvesting systems enable a household to participate more actively in the community effort of conserving water.

What is Graywater?

As its name connotes, graywater is of lesser quality than potable water, but of higher quality than black water. Blackwater is water flushed from toilets. Also, water from the kitchen sink, garbage disposal and dishwasher usually is considered blackwater because of high concentrations of organic waste. Graywater derives from other residential water uses. Water from the bath, shower, washing machine, and bathroom sink are the sources of graywater.

Not a water for all uses, graywater is most suitably used for subsurface irrigation of nonedible landscape plants. Graywater could supply most, if not all the irrigation needs of a domestic dwelling landscaped with vegetation of a semiarid region. Along with its application to outside irrigation, graywater can be used in some situations for toilet flushing.

Graywater derives from domestic water use. During 1989 residential water use for the three largest Arizona Active Management Areas (Tucson, Phoenix, and Pinal Active Management Areas) respectively was 116, 153, and 230 gallons per capita per day . Multiply this amount by the number of family members to determine a family's total water usage.

The amount of water a household uses for interior and exterior purposes determines to some extent the family's potential graywater supply and demand. A percentage of a household's interior use represents supply, and its exterior applications generally represent demand.

The amount applied to interior and exterior uses greatly varies among different households. For example, interior uses range between 100 percent to 20 percent of the total family water budget. About 60 to 65 percent of water applied to interior uses potentially can be recycled as graywater.

A household applies from zero to 80 percent of its total water budget for exterior uses depending upon a number of variables including type of landscaping, season of the year, residents' water use habits, etc. Graywater can be used to meet many exterior water needs.

As can be seen from the above figures graywater represents a possible water source to meet exterior-use water demands. For example, as much as 31 percent of Casa Del Agua's total water budget is recycled graywater. By storing winter graywater for use during the hot dry summer months, sufficient graywater is recycled to meet Casa Del Agua's landscape irrigation demands.

Pros and Cons of Graywater Use

The most obvious advantage of domestic graywater use is that it replaces potable water use. If graywater is used on vegetation, potable water is saved or conserved. Graywater use might be a fitting item on the water conservation agenda.

Not only does its use on landscape conserve potable water, but graywater actually may be better for plants, its use resulting in more vigorous vegetation. Graywater may contain detergents with nitrogen or phosphorus which are plant nutrients. It may also contain, however, sodium and chloride which can be harmful to some sensitive species.

With water costs rising, water, even graywater, will be considered a resource of greater value. This shift in perception might prod homeowners and policy makers to view graywater as a valuable domestic water resource. Unused graywater might be seen as money wasted, its use a financial advantage.

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Graywater use also offers potential financial advantages to regional sewage treatment facilities. Their capital and operational expenditures may decrease because graywater use diminishes sewer flows, thereby lessening the need to expand such facilities.

Diminished sewer flows from domestic graywater use may have a downside however. Some officials fear this situation will result in insufficient sewer flows to carry waste to the sewer plant. Others see this as an unlikely problem, except possibly for sewer systems lacking significant slope.

Officials also have voiced concern that with increased use of graywater, less effluent will be available for treatment resulting in less reclaimed water for municipal uses. This likely would be a problem for a community that reclaims all its wastewater. Domestic graywater use then would represent a decrease in municipal water supplies.

Concern is raised about the public health implications of graywater use. What, if any, health hazards arise with graywater use? What circumstances cause graywater to be hazardous to health? Most officials agree that more work and research is needed to determine the risks – and benefits – of graywater use.

Graywater Systems Vary

Graywater systems vary from simple low-cost systems to highly complex and costly systems. The technology involved in such systems ranges from the sophisticated to the crude, from engineered systems with filters and pumps to a washing machine draining directly onto oleander bushes. (Official acceptance correspondingly varies from approval to disapproval.)

Graywater recycling systems are commercially available. The more sophisticated graywater systems treat graywater prior to disposal to reduce groundwater contamination and surface ponding problems. Some of these systems are able to remove pollutants and bacteria from graywater. The better systems include settling tanks and sand filters. Improvement in technologies and systems' innovations regularly occur.

The system installed at Casa del Agua drains graywater from the household's water-using appliances into a 55-gallon sump surge tank. A filter is fitted over the graywater drain line where it enters the sump to remove lint and hair before the water is pumped to other components of the recycling system.

The sump fills to a level that activates a float switch and then the graywater is pumped into various treatment systems. The graywater then is pumped through an underground drip irrigation system to the landscape or for use in the toilet.

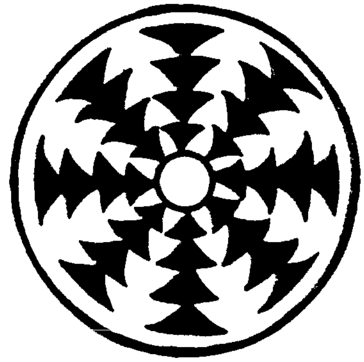
Construction of the Casa del Agua's graywater treatment and distribution system was about $1,500. Storage cost for 5,000-gallon tanks is estimated to be about $0.50 per gallon. Cost obviously are prohibitively high for an individual household to purchase and operate such a system.

The question of cost is an important issue relevant to both graywater use and rainwater harvesting. If installing such systems in the home is unduly expensive, their acceptance and use will be limited. Such systems may be viewed as impractical, or worse, elitist.

Such is not the case however. Expensive units are indeed available, but a person interested in graywater use and rainwater harvesting is not limited to these options. With a modicum of mechanical skills, a person can devise or improvise methods to use graywater or harvest the rain. In fact, these activities invite the ingenuity of backyard technology.

For example, a graywater use system was designed to recycle washing machine rinse water back into the washer for use in the wash cycle of the next load. Clothes thus are washed in the rinse water from the previous load, and water is saved.

This system consists of a 32-gallon trash container placed adjacent to a washing machine, but at a slight elevation. After the wash cycle has



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drained, the drain hose from the washing machine is removed from the sewer standpipe and positioned to drain the rinse water into the container. The rinse water later flows back into the washing machine through a one-inch gate valve for use in the wash cycle of the next load.

The device that stands as the archetypal graywater use method and which prompts the most enquiries to officials is the washing machine draining directly onto outside vegetation, usually oleander bushes. This is the image in many people's mind when the topic of graywater use arises. It also is a fitting image to begin discussion of graywater use regulations.

Graywater Regulations in Arizona

The Arizona Department of Environmental Quality regulates domestic graywater systems and, in some instances, specific counties are involved. Rules permit single and multi-family residences to use graywater for surface irrigation under certain conditions. These conditions include DEQ approval of the design and construction of the system. The system must include a settling or holding tank to settle out the grit and heavier material from the graywater. A filtration device is also required. If the graywater is to be applied to the surface a means of disinfecting the graywater also is necessary.

DEQ has delegated authority to the health departments of Pima, Maricopa, and Yavapai counties to perform this technical review of graywater use systems. The delegation agreement specifies the counties' areas of authority.

Also, graywater used for surface irrigation must meet allowable water quality and monitoring specifications. Allowable limits are set for fecal coliform and chlorine residuals. A sampling schedule also is established.

When discussing graywater use regulations an important distinction is whether graywater application is surface or subsurface. The above rules refer to surface irrigation. The rules define surface as extending two feet below the surface, although technical review officials generally interpret surface as 16 inches.

The water quality standards for surface irrigation are more stringent than what is required for subsurface use, defined as the area below the surface level. Subsurface use must meet water quality standards for groundwater.

Some critics claim that by defining surface area as two feet below the surface, the rules essentially intend that all graywater use will be surface use. Distributing graywater below two feet greatly limits its usefulness. Some critics claim it negates its usefulness.

The application of these standards discourage many people, at least those checking on the graywater source of most popular appeal – the draining washing machine. About 90 percent of people calling DEQ about graywater use want to drain their washing machine directly onto backyard vegetation. This decidedly is graywater surface irrigation.

First of all they would be told that graywater cannot be discharged directly on the surface where ponding will occur. Rules require that first the washing machine drain into a holding tank before drainage through an irrigation system. Then the water must be filtered and, since it is for surface use, it must be disinfected to meet established water quality standards. The fecal coliform level must be sampled daily which means testing by a state certified laboratory, at a cost of about $100 per sample. (At this point most people either give up the idea, or pursue it without official approval.) Fecal coliforms especially concern health officials because of possible surface settlement.

As would be expected this monitoring requirement discourages greater graywater use, at least legal graywater use. Some officials believe it could be changed, with no adverse health effects. They suggest that more research is needed to determine the quality of graywater coming from the various systems. The results then can be compared to regulated standards to determine if they are too high or strict.

For example, possibly a case could be made that fecal coliform sampling needn't be as frequent and that disinfection may not be needed. The fecal coliform concern historically was linked to washing cloth diapers. Today, fewer households have babies, and those that do often use disposable diapers or a diaper service.

Graywater Outlaws

Avoidance of graywater regulations is not uncommon. The person intimated by DEQ graywater use rules might go ahead anyway and drain the washing machine into the oleanders. The oleanders benefit, and no harm seems done. According to public health officials the draining washing machine is the most common graywater system outlaw. Complaints are filed weekly about such arrangements, usually by a neighbor whose yard is overflowing.

Draining water from bath and sink for external use is a more difficult task than draining a washing machine. For one, a washing machine has a movable drain hose to direct flow. Also many Arizona houses are built on slabs, thus presenting problems for getting at the necessary tub and sink plumbing points. These problems, however, are circumvented by using a centrifical pump to pump water from sink or tub directly out the window. Kitchen sink water sometimes is pumped to a compost pile.

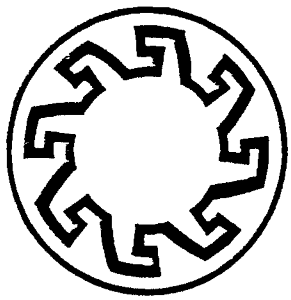
Health officials realize that graywater rules often are ignored and violated. Rules that are concerned with matters at the individual household level are not easily enforced. Graywater police are not the answer.

Some officials are troubled by the existence of unheeded laws. They argue that it is bad policy to have regulations on the books, to be variously enforced. Either consistently enforce them or create laws that are enforceable, they say. No take-it-or-leave-it laws wanted.

Others argue that the laws definitely should be changed, not so much from an enforcement perspective but because the laws are unduly restrictive. They argue that the laws need to be changed to allow greater application of graywater, to the benefit of water efficiency and water use policy in the state. They point to recent developments in California, Arizona's arch water competitor, where graywater laws recently were liberalized.

Others remain undecided whether it would be wiser to enforce present laws or pass new ones. They argue that information and facts presently are lacking to guide lawmaking. With more information available, good graywater use laws could be passed to regulate demonstrated hazards and promote beneficial uses. Again more research is the key.

Others interestingly defend the inherent goodness and virtue of the men and women of the soil. They admit that the graywater rules are indeed ignored but not to any bad effect. They say that unlawful graywater users generally are a benign lot, committed to gardening and protective of the environment. They are good, cautious people, not the type to create a public nuisance or threatening health conditions. Let them be.



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Some officials are specific about what legal changes are needed. Their experience leads them to believe that home graywater units generally are ill-maintained and inefficiently operated and, as a result, often are health hazards. They call for regulated monitoring.

They often discover during inspections of residential graywater use sites that the system is changed from what originally was approved. For example, the property may be relandscaped. Or the disposal calculations may have been off, with the result that more graywater is available than the surface can absorb. Runoff or ponding becomes a problem. Sometimes cross connections are improvised, with a graywater system connected with the potable system because not enough effluent is being produced.

They say people begin with good intentions to maintain their systems but often do not follow through. They point out that the typical homeowner has trouble maintaining a swimming pool, a very visible and even personal appliance or attraction. What then might be expected when a graywater use system is to be maintained?

These officials stress the need to require monitoring of domestic graywater use systems to ensure proper operation and maintenance. They want regular inspections to be arranged, possibly through a maintenance contract. This also would ensure that required testing is done, with results reported to county or regional agencies.

The California Connection

No single understanding of the benefits and hazards of graywater use guides policy makers. A considered hazard in one state might be viewed more benignly in another state. This situation is demonstrated by reviewing California's recent legislative action liberalizing its graywater use rules. California's graywater policy presents an interesting comparison with the situation in Arizona.

Before the new regulations, graywater use in California was not legal. Graywater was considered wastewater, and all wastewater had to go to an approved sewer or septic system. Despite this regulation, many people were using graywater to water their vegetation. Californians were experiencing a lingering drought, and graywater applied to the landscape saved potable water—and also the landscape.

Confronted with this situation, officials had several options. They could enforce the law, ignore the violations, or provide useful guidelines to ensure safe, and efficient graywater use. They chose the latter. The California legislature passed a law in 1992 legalizing graywater use in cities and counties of California. The legislation directed the California Department of Water Resources to adopt standards for the installation of graywater systems and the use of graywater.

The CDWR standards define graywater as untreated single-family residential wastewater from all sources, excluding toilet, kitchen sink, and dishwasher. Graywater use is to be limited to subsurface application through drip and mini-leachfield irrigation systems.

The definition of subsurface is defined according to soil types. Minimal subsurface depth for sandy soils is eight inches, with a greater depth set for clay soils, between about ten and 12 inches. Arizona law defines subsurface as below two feet. Graywater use above this level is considered surface use and is regulated accordingly. Surface water quality standards are stricter than those for subsurface.

In California an approved subsurface drip irrigation system must have a surge tank of between 50 to 100 gallons to collect the graywater. When it reaches a certain level, the water is pumped from the tank through the drip irrigation system. Filtration is required for graywater use in drip irrigation systems. With a mini-leachfield irrigation system a surge tank is not required. The graywater flows directly into the leachfield.

The above systems do not require the holding or settling tank that Arizona's regulations specify. Also, California does not require the graywater sampling, monitoring and treatment that is necessary for graywater surface use in Arizona.

Cities and counties in California have the option of accepting the state's graywater standards or establishing their own, using the state's minimal standards as a base. They even can decide to ban graywater use altogether.

Besides providing uniformity, the California law offers citizens an advantage when lobbying their cities or counties to legalize graywater use.

With the new law citizens no longer have to argue why graywater use should be legalized. It now is up to governing bodies that are in opposition to graywater use to explain why it should not be legalized.

California's graywater use policy reflects a belief that the hazards of graywater use often are greatly exaggerated and that many states have adopted an overly protective public health position. California officials in support of the new regulations argue that many people regularly use graywater, and they claim no evidence exists that anyone has become ill from its effects.

These officials point out that research on the public health hazards of graywater use is very limited, with no data indicating a problem – or non-problem, for that matter. There is research however that shows that bacteria levels in soil generally are extremely high from dogs, cats, birds, and other sources. As a result, no significant difference exists in the bacterial levels of the soil between graywater and nongraywater use.

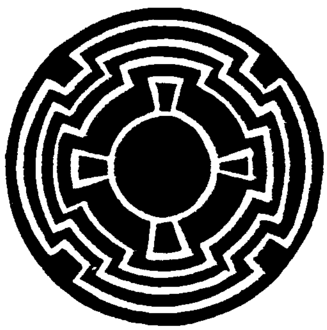
Some observers see a relevancy to Arizona in the California scenario. Drought prompted California to graywater use. The increased expense of Central Arizona Project water may have the same effect on Arizona. People will seek strategies to economize on their water budgets to compensate for the higher water bills. Obstacles to graywater use might be questioned and challenged.

The above comparison is not intended to demonstrate the righteousness of one position or the other. Instead, the comparison intends to demonstrate that differences of opinion – and therefore policy – exist regarding graywater use.

Harvesting the Rain

Rainwater harvesting is collecting rainfall to meet water needs. A rainwater harvesting system concentrates and collects for direct use and storage rain falling on house and grounds. Free, literally falling from the sky and unhindered by government regulations, harvested rainwater splendidly augments domestic water resources. Rainwater supplies about eight percent of the total water needs of the resident family at Casa del Agua.

Rainwater harvesting in the United States is of sufficient importance to inspire a publication: "Raindrop – Rainwater Harvesting Bulletin." In a recent issue Dennis Lye, a microbiologist with the U.S. Environmental Protection Agency, reported that many individuals, and



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even communities regularly use stored rainwater to meet or supplement clean water needs. He stated that about 200,000 cisterns are in use in the U.S. collecting and storing rainwater.

Water is collected or harvested from concrete patios, driveways and other paved areas. Also harvested is the flow from the roof and from catchments such as gutters. Houses can be designed to maximize the amount of catchment area, thereby increasing rainwater harvesting possibilities.

At Casa del Agua, six hundred square feet of additional catchment area was added to the porch and greenhouse roof to maximize runoff. This additional surface increases the amount of collected annual rainfall by more than 3,700 gallons. Downspouts are located about every 20 ft. along the gutter, instead of the more common 40 feet. This ensures that heavy rains will not likely overflow the gutter and instead will flow to catchments.

Rainfall harvesting has limitations not shared by graywater use. Graywater is a fairly predictable and dependable water source. Household water use occurs consistently producing various, but regular amounts of graywater. Rainwater harvesting lacks this dependability, relying instead on the variability and vicissitudes of climate for its water source.

Also, graywater is more readily stored than rainwater, with less cost. Since it is a dependable source, its storage system does not have to be very large. A typical residence could get by with about a 1200-gallon tank, the size of the standard concrete septic tank. Being infrequent, rainfall requires a larger storage capacity so supplies can carry over between desert rainfall events.

Collected and stored rainwater can be used in evaporative coolers, toilet flushing, car washing, chlorinated swimming pools, and surface irrigation, especially in food gardens. In the United States harvested rainfall mostly is used for irrigation, with limited other domestic uses. At Casa del Agua, where the landscape is almost entirely watered by graywater, rainwater primarily is used in the evaporative cooler, with a limited amount used for toilet flushing.

Rainwater Harvesting Systems

Rainwater harvesting systems vary from the simple and inexpensive to the complex and very costly. Directing rainfall to plants located at contoured low points is a very simple rainwater harvesting system. Falling rain then flows to vegetated areas. This strategy is demonstrated at Casa del Agua where the grounds are contoured to direct rain to plants. No rain escapes property boundaries. More complex rainwater harvesting systems include storage of rainfall.

Rocky Brittain, research associate with the University of Arizona's College of Architecture, designs rainwater harvesting systems for various facilities, including private homes. He begins by conducting a complete water balance analysis by noting the location of plants to be irrigated, the monthly rainfall in the area, and the available options for concentrating rainfall directly to the plants.

By computing expected rainfall and vegetation water needs Brittain is able to determine whether storage is required and, if required, the monthly storage need. He then is able to size the appropriate storage system. Tanks are an expensive item, with the excavation cost to install a tank sometime equal to the cost of the tank.

Rainfall is stored in steel or concre te tanks. Brittain improvised a rainwater harvest storage tank using a swimming pool. A lid was installed on the pool and buried beneath a driveway. The result was a rainwater storage tank 40 ft. by 8 ft. and 8 ft. deep, with a capacity of 20,000 gallons at a cost of about $22,000. About one dollar per gallon is the average cost for most underground storage units.

The least expensive rainwater storage system makes use of an above-ground swimming pool, with a lid or cover to reduce evaporation. Rainwater then can be stored for about .07 cents a gallon. The financial advantages however may not outweigh the inconvenience of living with this unsightly above-ground unit taking up a large area of the backyard.

Casa del Agua's rainwater storage capacity is about 8,000 gallons. An inline filter separates particles of dirt, sticks, leaves, and other debris before the rain flows into the cistern. The filter consists of a concrete box through which the water flows passing through a window screen filter.

Rainwater harvesting is an everyman's water augmentation method. Any container capable of holding rain dripping from roof or patio can be a rainwater harvesting system. A plastic garbage barrel is sufficient. Sturdier and more elegant containers create a more pleasing effect and some are built using backyard technology. For example, small ferro cement tanks can be constructed to collect water at the base of down spouts.

Rainwater Quality

The image of falling rain may be pure and refreshing but harvested rain is not without water quality concerns. Rain in certain urban areas may contain various impurities absorbed from the atmosphere, including arsenic and lead.

Certain desert conditions also can cause rainwater quality concerns. Desert rain is infrequent and, therefore, bird droppings, dust and other impurities accumulate between rain events. They then occur in high concentrations in runoff when it does rain. As a result, the quality of harvested rainfall needs frequent monitoring if it is used for potable uses.

Various methods are used to purify rainwater. First-flush devices ensure a certain degree of water quality in harvested rainwater. The first five gallons of runoff from a gutter, roof or other surface is likely to contain various impurities such as bird droppings and dust. A first-flush device prevents this initial flow from draining into the storage tank.

Many first-flush devices are simply and cleverly designed. Such devices include tipping buckets that dump when water reaches a certain level. Also there are containers with a ball that floats with the rising water to close off an opening after an inflow of five gallons. Water then is diverted to another pipe leading to the cistern. This use of simple technology is an attractive feature of rainwater harvesting. (Water harvesting systems are not readily available on the market.)

It is difficult to determine how many people are harvesting rainwater for domestic uses. This is because many systems are backyard creations, constructed of available materials, creatively worked out and improvised, needing neither permit nor license; e.g., a plastic garbage barrel collecting rain flow from a roof. Will harvested rainfall achieve any importance as a water resource in the state and to what extent?

Arizona is a semiarid state. Its limited rainfall means less rain is available to harvest. What rain occurs mainly falls during two periods of the year: summer and winter. This means ample and sufficient quantities would need to be collected and stored to ensure a supply during the intervening dry spells.

The complex rainwater harvesting systems that collect and store large quantities of rainwater, however, are very expensive to install and require ample financial resources. It would seem unlikely therefore that such rainwater harvesting systems will be widely used in Arizona. Rainwater harvesting as a water augmentation method likely will be limited to the simpler catchment and distribution methods; i.e. plastic garbage cans and channeling of surface flow.

Conclusion

Graywater use and rainwater harvesting are not high-profile water resource topics within Arizona. Possibly this is because Arizona is more concerned with reuse and augmentation options that promise bigger payoffs; e.g., municipal treatment and distribution of effluent and the Central Arizona Project.

Or maybe Arizona has not actively promoted graywater use and rainwater harvesting because its water conservation need has not been that extreme. In fact, some people question whether the state's water resource picture is really that dire to justify strenuous conservation practices. After all there seems to be a surplus of CAP water.

Also cost is a concern. Graywater ruse and rainwater harvesting systems can be expensive items, beyond the budgetary range of most households. Unless less expensive systems become readily available, households are unlikely to invest in such products, even to serve a good cause such as water conservation.

Certain situations may arise, however, to urge Arizona to examine seriously all available reuse and augmentation options. Water prices may rise sharply. Drought may occur. Graywater use then might be viewed as a worthy water resource possibility. Rainwater harvesting might also prove useful in more limited situations.

The state's rules regulating graywater use need to be reviewed to determine if present rules are unduly restrictive. That the rules are ambiguous in certain areas presently is apparent. For example, to some officials state rules allow domestic graywater use only in situations where connection to a public sewer system is impractical. This would be a very restrictive ruling and generally has not been applied. The situation, however, points to the need to review current Arizona graywater rules.

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