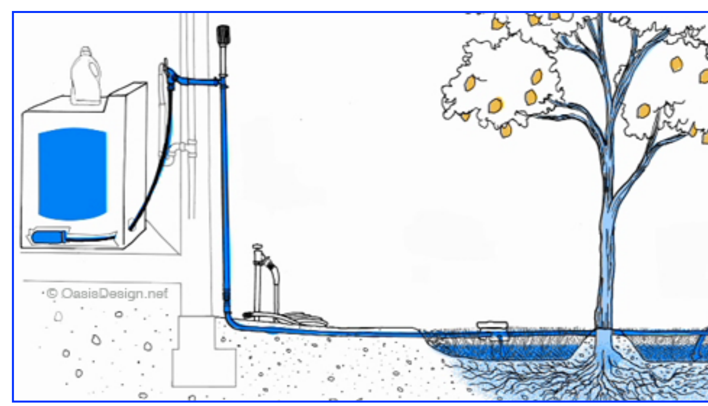
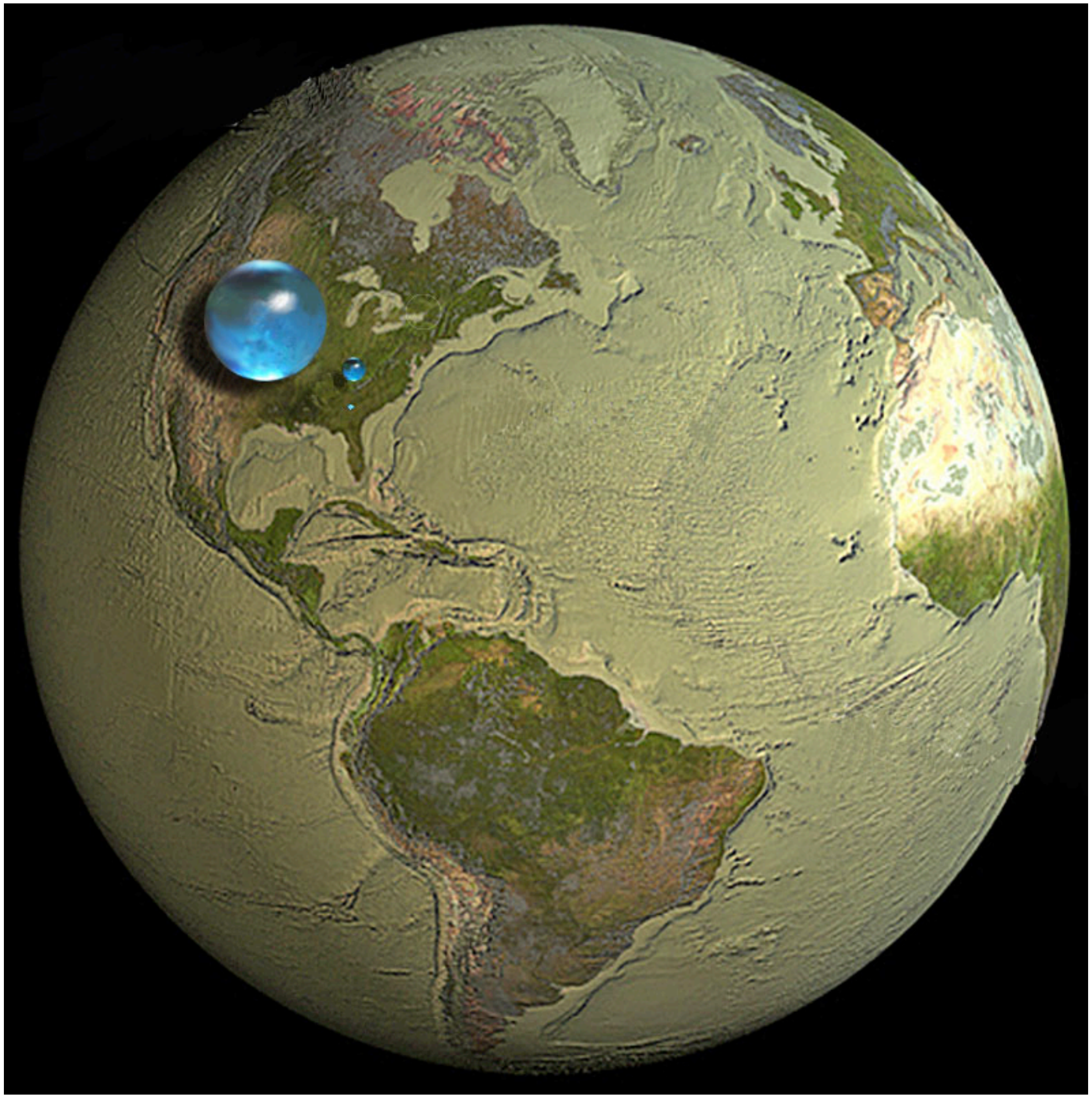
Considerations on the quality & management of alternative irrigation water sources


Passion Puddle @ SEBS, Rutgers University



Raul I. Cabrera
Rutgers University

Water: A limited and limiting resource



Less than 1% of all water on planet is fresh water fit for most animal and plant use.

Large drop= ALL water on planet; 860 mile dia. ~333 million mile^3.

Medium drop= Liquid fresh water; 170 mile dia. (0.77%)

Small drop= River and lake water; 35 mile dia. (0.01%).

Earth's diameter is 7,926 miles.

The shallowness of the oceans is clearly evident.

Credits: H. Perlman (USGS); illustration by J. Cook (Woods Hole Oceanographic Inst.). **Data from:** I. Shiklomanov. 1993. World fresh water resources. In: P.H. Gleick (ed.), Water in Crisis: A Guide to the World's Fresh Water Resources, Oxford Univ. Press, New York.

Need for alternative irrigation water sources

- Availability of high-quality water supplies endangered by climate change (drought) and stiff competition for pressing human uses and activities.
- Ornamental plant (nursery, greenhouse, sod) production uses large water volumes and high application rates (>80" per year are common).
- Landscape irrigation is the largest user of water in urban areas, accounting for ≥50% of the total residential potable water use in many SW-USA cities.

Bailey et al., 1999; Cabrera et al., 2013; EPA, 2009; Fare et. al., 1992; Roesner et al., 2006; Warsaw et al., 2009

Dealing with limited supplies of good-quality water and alternative water sources

- ✓ **Use the right plants for the site** (*climate, soil & rain*)
- ✓ **Use the right water for the right use** (edible *vs* ornamental)
- ✓ **Use BMPs** *(e.g. OM, mulching, efficient irrigation equip. & methods)*
- ✓ **Alternative water sources** (*quality issues!*)
  - ➢ Agricultural tailwater/Recycled water
  - ➢ Naturally saline/brackish water
  - ➢ Municipal reclaimed water
  - ➢ Rainwater & stormwater
  - ➢ A/C Condensates
  - ➢ Residential Graywater

From: Cabrera et al., 2018 (HortTechnology 28(4): *In Press*)

The right plants (*adapted & native*) for the site (*soil, climate, water quantity & quality*)

Irrigation Water Quality – Horticultural Considerations

- Understanding water quality is imperative for successful production and management of quality ornamental plants/crops.
- It is the most important factor that dictates site selection, trees and plants to grow, irrigation methods, fertilization programs and their management.

pH - alkalinity issues

(pH >7 and alkalinity >150 mg/L)

Photos: R.I. Cabrera

HCO_3- Deposits

When >90 mg/L

Salinity stress (components)

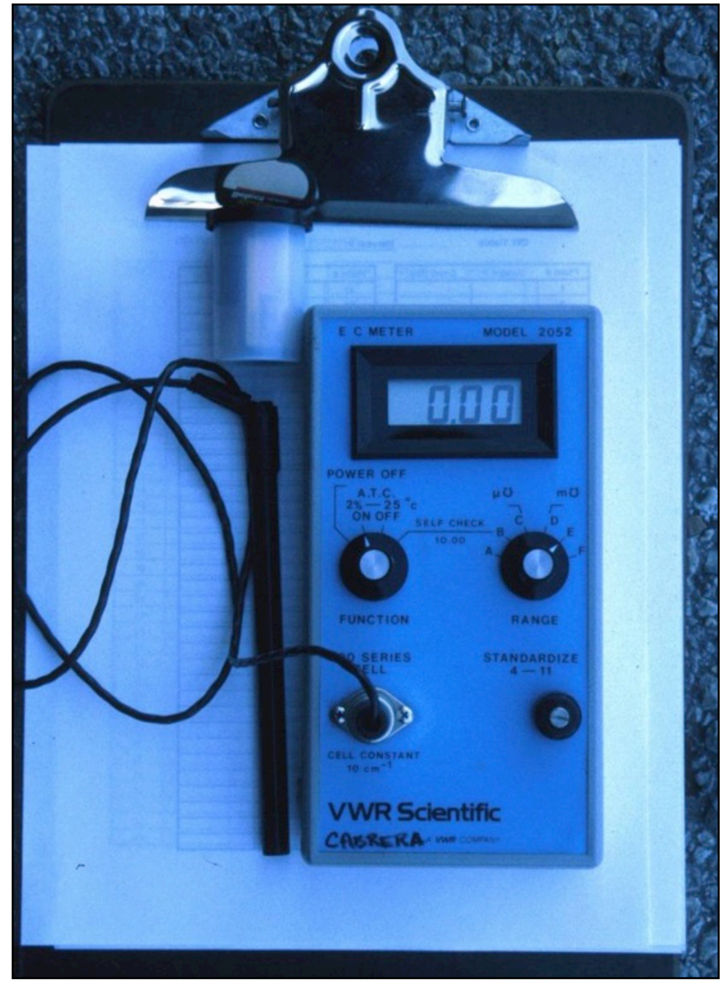
All ions in solution contribute to overall osmotic effect (EC>1 dS/m) , but Na, Cl (>70 ppm; B>1 ppm) most commonly cause specific toxicity effects.

Osmotic stress: makes plant water uptake difficult to impossible

Nutrient imbalances


Iron (Fe) deposits *(staining)*
When >1 mgl/L (also for Mn)
Photo: R. I. Cabrera

At a minimum, monitor pH & EC routinely in all growing operations (*no excuses*)



Use quality meters – & calibrate them!

Irrigation management depending on water source

CRITERIA	Good Quality Source	Alternative Water Source	Blend (Good + Alternative)
Quality Tracking: Frequently (*pH/Alk; EC, Na, Cl, B*) Continuously	✔ (Groundwater, *surface*) ✔ (Surface, *groundwater*)	--- Preferred	At least Preferred
pH/Alkalinity Adjustment	Rarely	Frequently to Continuously	As needed
Irrigation Method: Overhead Microsprinkler/Spray-stake/Spitter Bubbler, Drip	Yes (*Least efficient*) Yes (*Efficient*) Yes (*Most efficient*)	**NO** Yes Yes (w/filtration)	Depends on Q Yes Yes (w/filtration)
Leaching fraction (LF):	Lowest (Try to keep <10%)	Highest (≥30%; adjust with quality)	Intermediate (10%-30%)
Fertilization	Monitor thru EC; *Reduced CRF + dilute fertigation is applicable*	Monitor/adjust ***continuously*** thru LF (**monitored fertigation is preferred**)	Monitor/adjust ***frequently*** thru LF (**Use stable CRFs <u>OR</u> monitored fertigation**)

From: R. I. Cabrera (2018)

Chemical quality parameters in suitable and alternative water sources for irrigation of ornamental/landscape plants

Chemical Parameter	Suitable Water	Mildly Brackish Aquifer	Municipal reclaimed water					Residential Graywater
			Santa Rosa, CA	El Paso, TX	San Antonio, TX	Lake Buena Vista, FL	Evesham, NJ	
pH	6.0 – 8.0	7.3 – 8.3	7.3	7.2 – 7.8	7.2 – 7.5	7.1 – 7.9		6.4 – 8.7
EC (dS/m)	< 1.0	1.6 – 4.7	0.7	1.5 – 1.9	0.9 – 1.2	0.6 – 0.7	0.5 – 0.6	0.3 – 1.4
Na (mg/L)	< 70	50 – 560	82	160 – 280	90 – 102	74 – 100	54 – 58	30 – 480
Cl (mg/L)	< 110	30 – 510	---	200 – 340	135 – 190	99 – 140	56 – 61	3 – 140
B (mg/L)	< 1.0	0.1 – 0.4	0.4	0.2 – 0.3	0.2 – 0.3	---	0.2 – 0.3	0.4 – 1.5
HCO_3^- (mg/L)	< 110	105 – 250	---	194 – 220	259 – 305	---	142 – 153	70 – 470
SAR	< 6.0	2.8 – 8.7	---	5.1 – 9.0	2.4 – 2.6	---	2.3 – 2.4	4.2 – 28.1

From: Cabrera et al., 2018 (HortTechnology 28(4): *In Press*)

Stormwater

Water from roofs, parking lots, roads and impervious surfaces. Goes to sewer systems and (mostly) to surface water bodies. <u>Can be routed to designed ponds & rain gardens.</u> <u>Quality is highly variable</u>; generally laden with salts, oils, sediments & other chemicals.

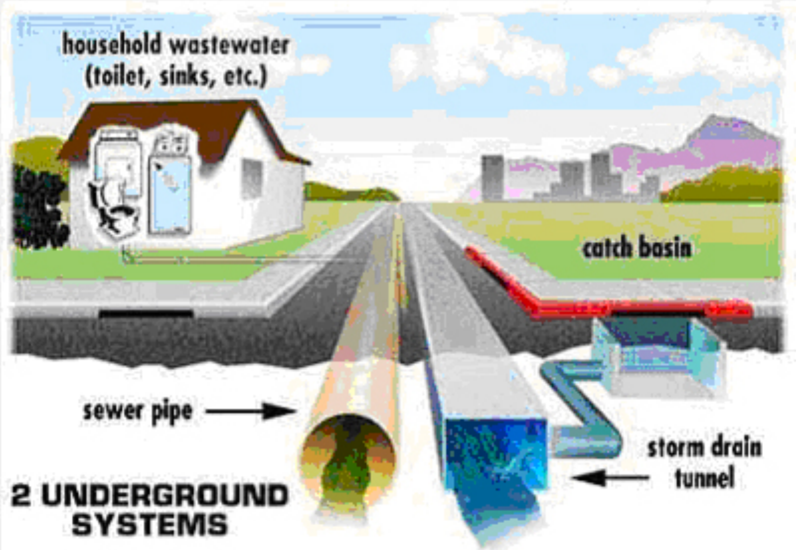
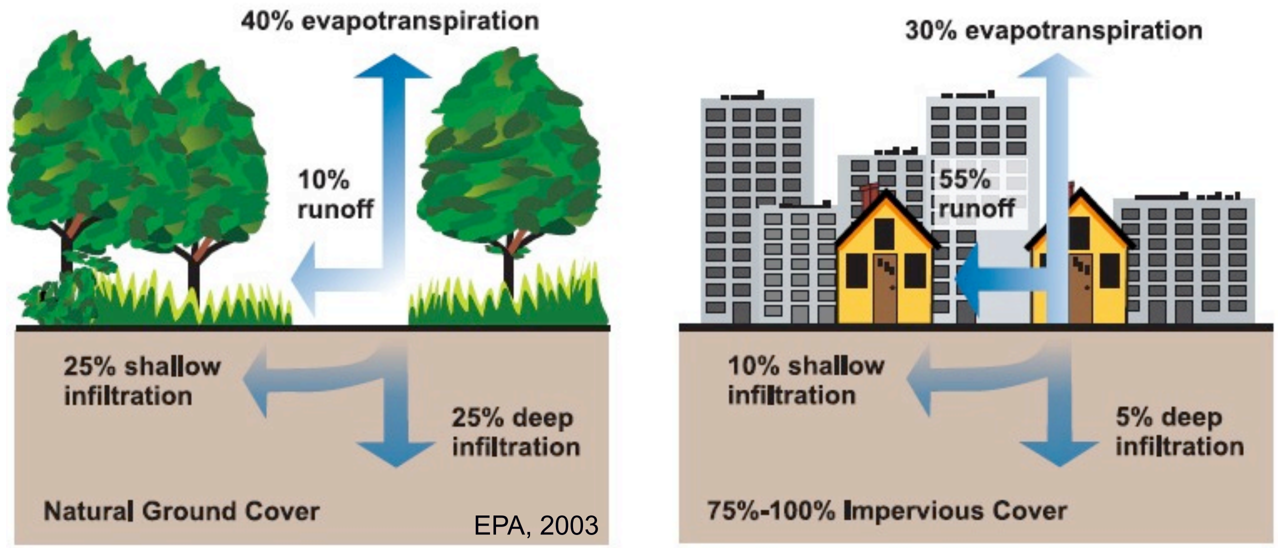


Illustration: City of Chandler, AZ



Rainwater

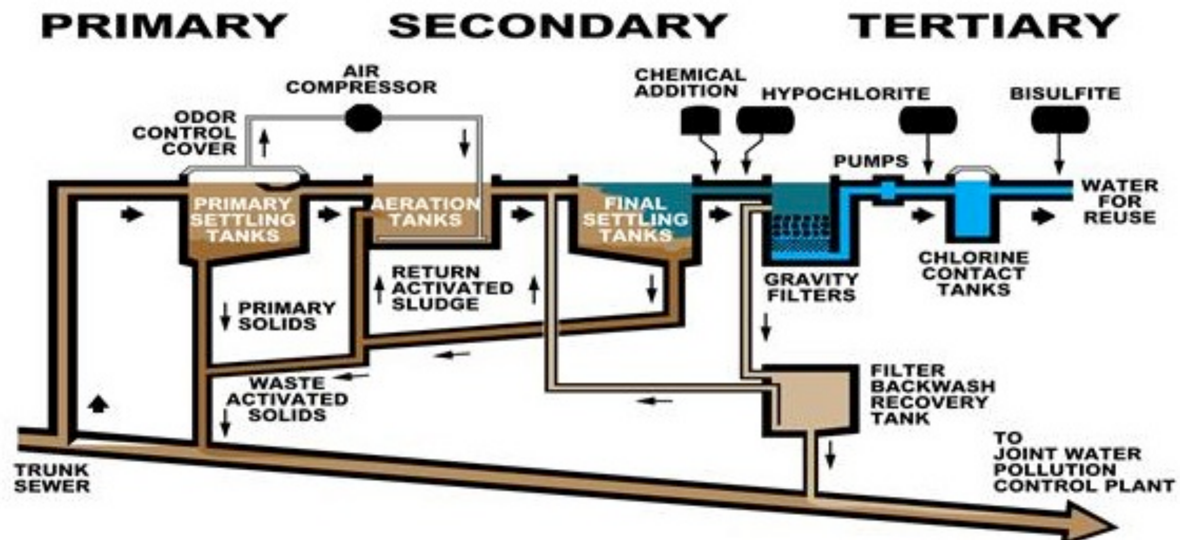
Rainwater from roofs; best quality; limitations with volume capture and storage, along with severe/prolonged drought periods.

22,000 gallon rainwater tank at Texas A&M R&E Center in Uvalde.

Good enough for a single 0.6” irrigation to the landscape (66,000 ft^2= 1.5 ac) in this facility!

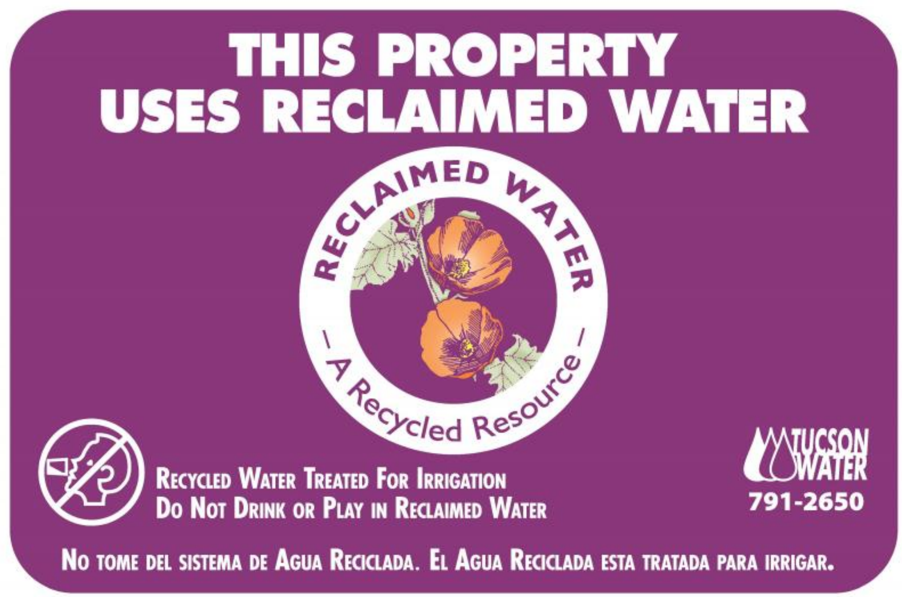
Reclaimed (recycled) Water

Photo: City of Clermont, FL



Source: Pomona (CA) Water Treatment Plant

Photo: Dept. of Ecology, State of WA



Reclaimed Water

- Sewage water processed by municipal water plants (*treatment methods: preliminary, primary, secondary and advanced*)
- Availability not interrupted by drought
- Quality can be highly variable (nutrients, salts, alkalinity)
- Its use is highly regulated: protection of public health is paramount (restricted use where human contact is likely)
- Handling and distribution requires separate plumbing (*with identifying color= purple*) from treatment plant to end-users.
- Successful use requires routine monitoring of its quality to minimize negative effects on plants and soils.

Water quality comparison based on level of total coliform bacteria

Water Source	**MPN/100 mL** *(Most Probable Number)*
Drinking Water	<1
Disinfected Tertiary Recycled Water	<2.2
Disinfected Secondary Reclaimed Water	<23
Undisinfected Reclaimed Water	20 to 2,000
Graywater	100 to 100 million
Raw Wastewater	Millions to billions

From: Sheikh, 2010

Photos: R.I. Cabrera

Reclaimed water extensively used in golf courses and public landscaped areas

Foliar salt damage from reclaimed water irrigation

Miyamoto et al.

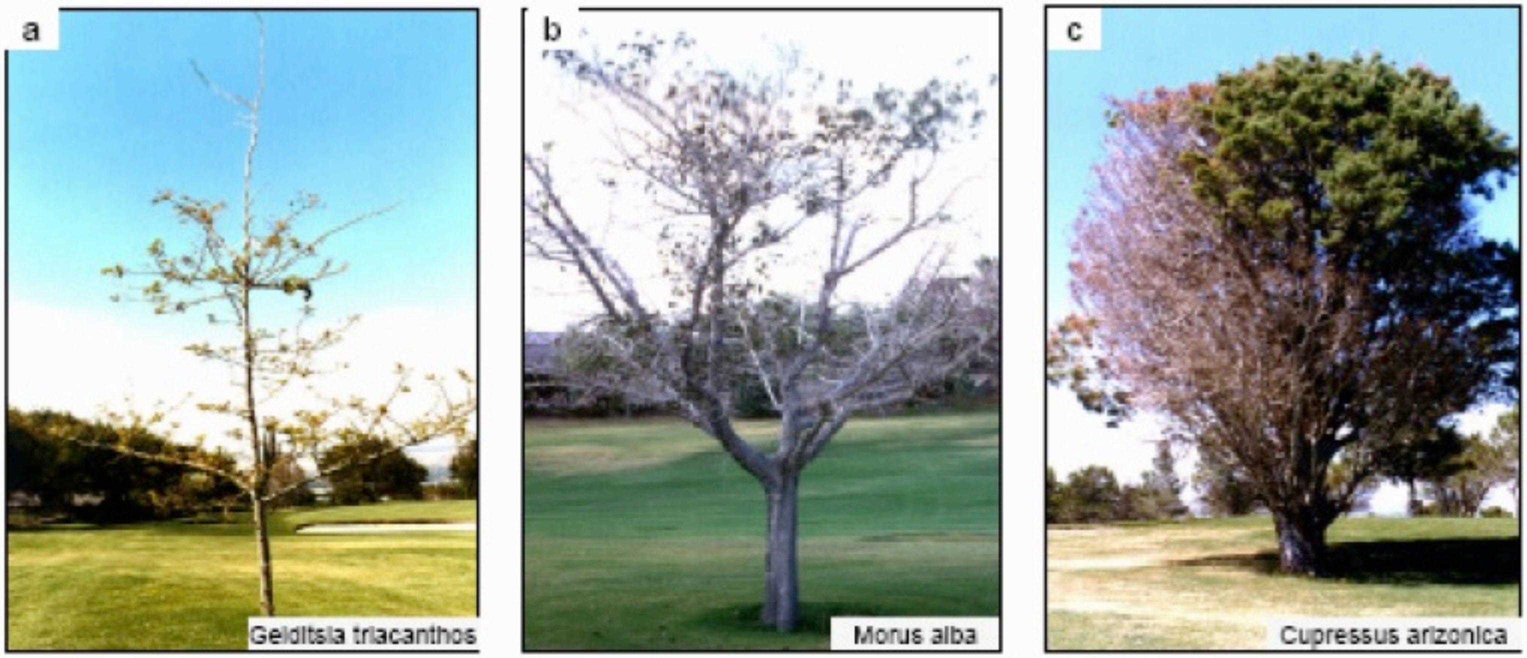
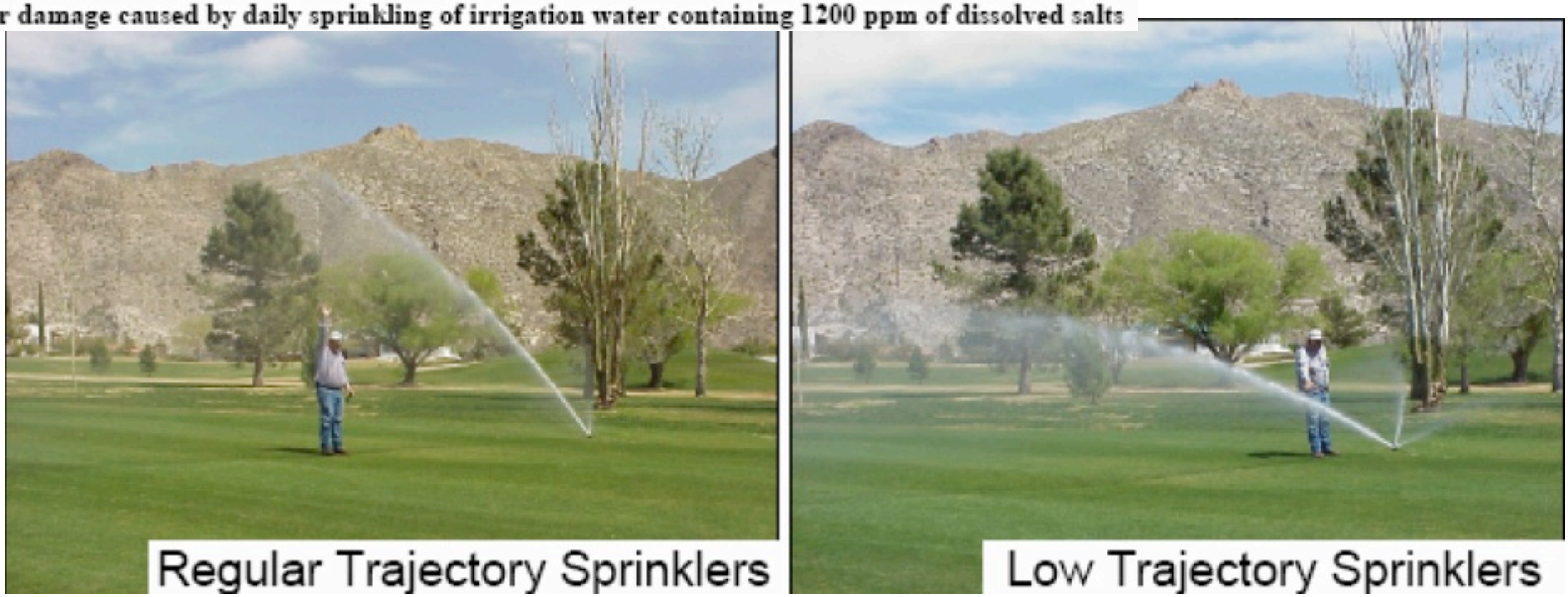


Fig. 1. Foliar damage caused by daily sprinkling of irrigation water containing 1200 ppm of dissolved salts



Estimated irrigation applications required to leach soluble salts from soils	
Percentage of Salt Reduction	**Required Irrigation Rate**
50%	6 in (150 mm)
80%	12 in (300 mm)
90%	24 in (600 mm)
Example: If the EC*e* of a landscape soil is 8 dS/m, and we want to reduce it to 4 dS/m (50% salt reduction), an irrigation rate of 6 inches will be required, equivalent to 3,740 gal/1,000 ft^2 (24,300 gal. in a 6,500 ft^2 home landscape)	

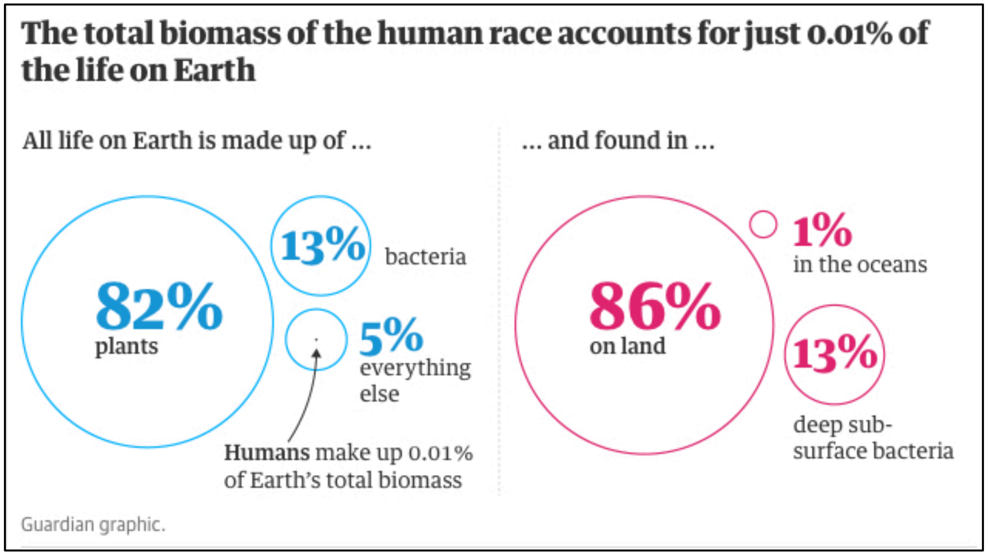
Source: Cardon, Davis, Bauder and Waskom (2007)

Soil Microbiology in site irrigated w/reclaimed water

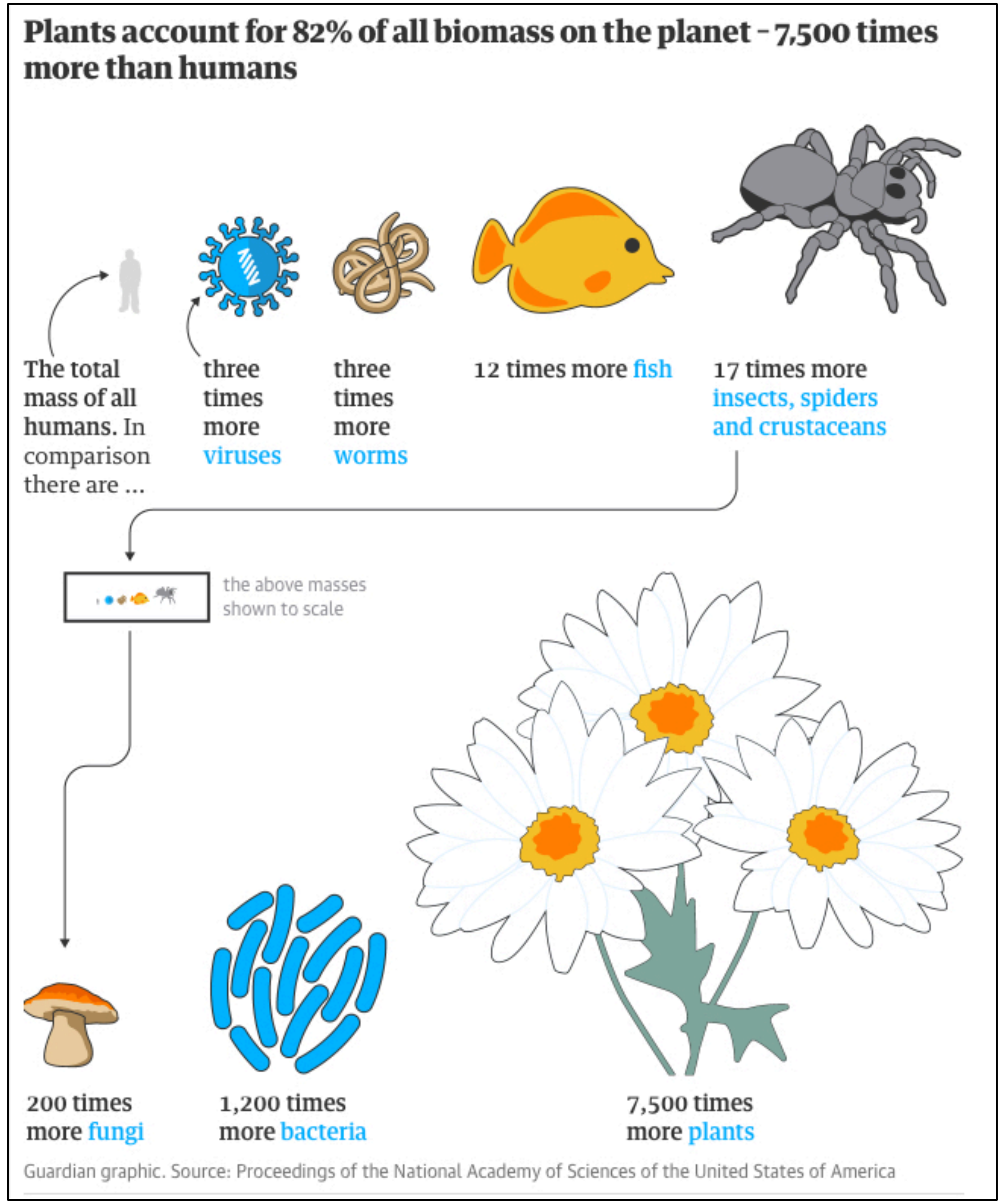
	Rainwater		Tap Water		Reclaimed Water	
Total Living Microbial Biomass *(PLFA ng/g)*	**3,808**		**5,961**		**5,012**	
Functional Group Diversity Index *(<1.0 to >1.6)*	**1.57** (very good)		**1.60** (very good)		**1.45** (good)	
Functional Group	**Biomass (PLFA ng/g)**	**%**	**Biomass (PLFA ng/g)**	**%**	**Biomass (PLFA ng/g)**	**%**
Total Bacteria	**2,177**	**56**	**3,203**	**54**	**2,214**	**46**
Gram (+)	1,199	32	1,757	30	1,347	28
Actinomycetes	391	10	587	10	367	8
Gram (-)	918	24	1,445	24	867	18
Rhizobia	56	2	93	2	53	2
Total Fungi	**482**	**12**	**633**	**11**	**361**	**8**
Arbuscular Mycorrhizal	154	4	259	4	82	2
Saprophytes	328	8	374	6	279	6
Protozoa	**38**	**1**	**120**	**2**	**20**	**0**
Undifferentiated	**1,171**	**31**	**2,006**	**34**	**2,416**	**46**
Solvita CO_2 burst-ppm CO_2-C	**127**		**157**		**94**	
Organic Matter - % LOI	**5.50**		**8.47**		**3.60**	

Note: *Data are means of three (n=3) composite soil replicates (vegetated with cool-season turfgrass)*

Cabrera (2017, unpublished)

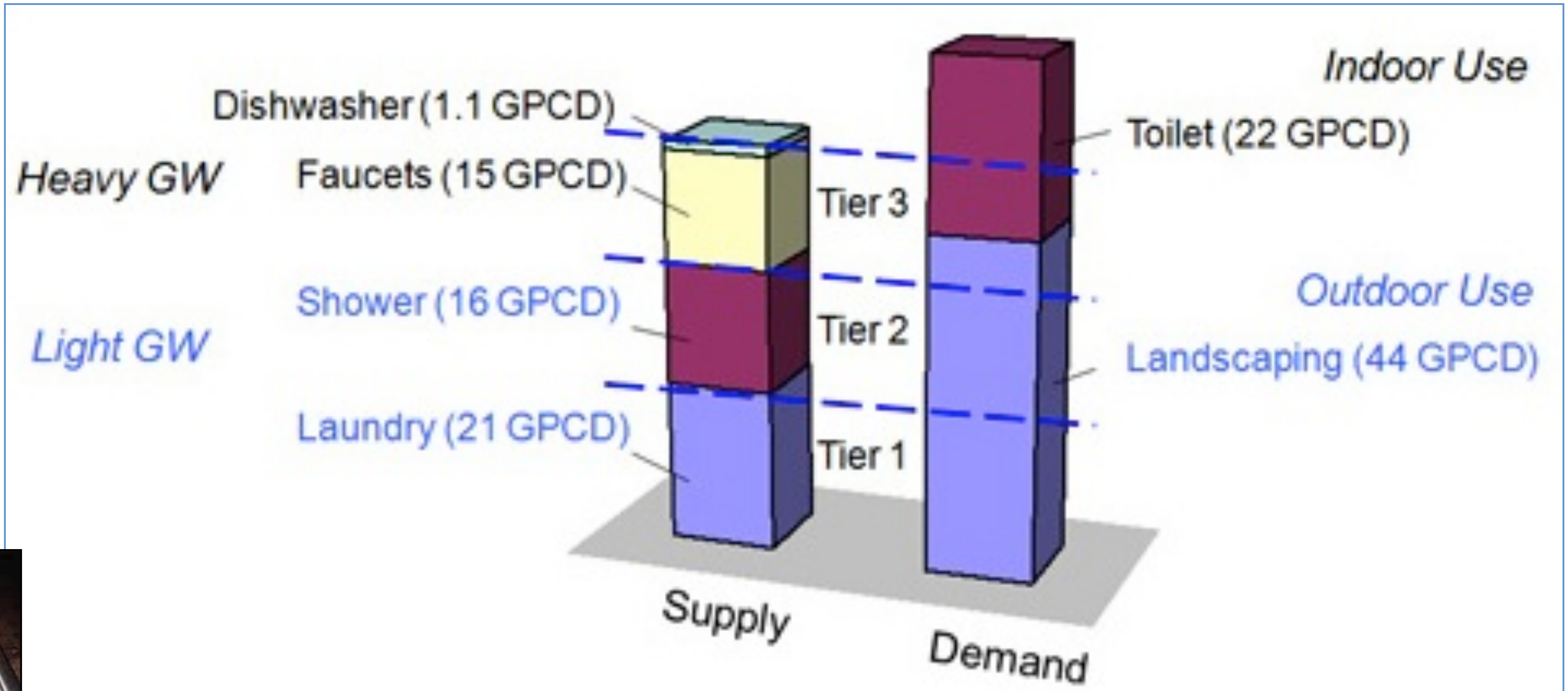


How important are microorganisms?



Bar-On, Y.M., R. Phillips, R. Milo. 2018. The biomass distribution on Earth. *Proc. Nal. Academ. Sci.*

Graywater: Untreated household wastewater from bathtubs, laundry, and showers. Accounts for 50-65% of total household wastewater (*EPA, 2012; Roesner et al., 2006; Sheikh, 2010*)



Potential for potable water savings in the residential sector of southern California with graywater reuse (Y. Cohen, 2009)

Short- & long-term effects of graywater irrigation

Plant growth-aesthetics & soil properties (SS, microbiology, physico-chemical) in research plots & residential sites irrigated with laundry graywater.

Including alternative (biodegradable/environmentally-friendly detergents and bleaching agents) graywater treatments.

Photos: R.I. Cabrera

Treatment	*pH*	***EC*** dS/m	**Chlorine (mg/L)** *Free*	*Total*
Tap Water	6.9	0.5	0.3	0.3
Detergent	7.2	0.5	0.6	0.4
D+Softener	7.2	0.5	0.6	0.3
D+S+Bleach	7.7	0.8	48.3	63.4

Graywater w/bleach has high Cl_2 concentrations - harmful to some plants and soil/substrate microorganisms.

Alternative bleaching agents (peroxide based) are highly alkaline and sodic – harming some plant species.

Landscape graywater study – Preliminary Results

Photo: R.I. Cabrera

Preliminary landscape graywater irrigation study

Phospholipid Fatty Acid (PLFA) Soil Microbial Community Analysis

	Control (well water)		Graywater (D+S+B)	
Total Living Microbial Biomass *(PLFA ng/g)*	**1,644**		**883**	
Functional Group Diversity Index *(<1.0 to >1.6)*	**1.57** (very good)		**1.2** (slightly below avg.)	
Functional Group	**Biomass (PLFA ng/g)**	**%**	**Biomass (PLFA ng/g)**	**%**
Total Bacteria	**881**	**54**	**439**	**50**
Gram (+)	539	33	310	35
Actinomycetes	213	13	101	11
Gram (-)	342	21	130	15
Rhizobia	12	0.7	0	0
Total Fungi	**183**	**11**	**25**	**3**
Arbuscular Mycorrhizal	52	3	0	0
Saprophytes	131	8	25	3
Protozoa	**21**	**1**	**0**	**0**
Undifferentiated	**558**	**34**	**419**	**47**

Cabrera et al. (2018, HortTechnology 28(4): *In Press*)

Thank you!

cabrera@njaes.rutgers.edu

Photo: M. Duff