Wastewater Reuse for Agriculture: Development of a Regional Water Reuse Decision-Support Model (RWRM) for Cost-Effective Irrigation Sources

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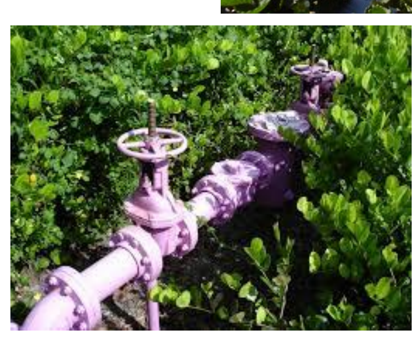
Introduction

- Wastewater Reuse Facts
  - California (since 1890)
    - ✓ Agricultural water use: 35-45 MAF per year
    - ✓ Treated wastewater: 5 MAF per year
    - ✓ Current wastewater reuse: 450-580 thousand AF per year
  - Israel (since 1948)
    - ✓ 75% of wastewater is reused for agricultural irrigation
  - Australia (since 1990s)
    - ✓ 10% of water used in mainland capital cities is reused for toilet flushing and landscape irrigation
- Wastewater Reuse for Irrigation
  - Cost reduction in synthetic fertilizers

  - Suitability for Irrigation
    - ✓ Salinity
    - ✓ Heavy metals
    - ✓ Pathogens
    - ✓ Potential PPCPs and EDCs



Objectives

- Develop a regional water reuse decision-support model (RWRM)
  - Cost-effective irrigation solutions
    - ✓ Citrus
    - ✓ Turfgrass (Unrestricted vs. Restricted access)
  - Cost reduction in synthetic fertilizers

Model Scenarios

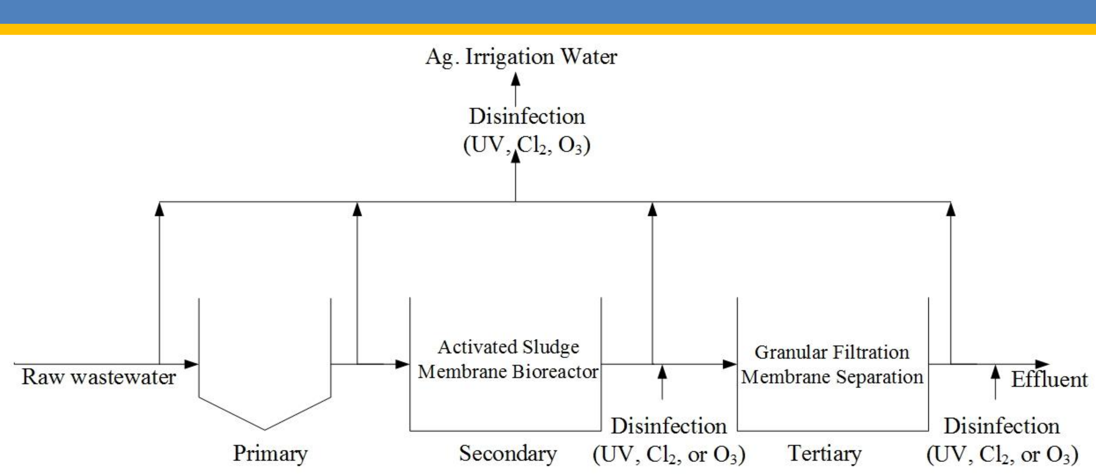


Figure 1. Schematic of Water Reuse

- Scenario A: With crop nutrient guidelines (Baseline)
  - Using irrigation guidelines for each crop
    - ✓ Based on average concentrations of constituents of interest in typical irrigation surface/groundwater
- Scenario B: Without crop nutrients guidelines
  - Insufficient nutrients in wastewater to cause harm
- Scenario C: Without crop nutrient and bicarbonate guidelines
  - Residual Sodium Carbonate (RSC) ≤ 1.25 meq/L

Modeling Methodology

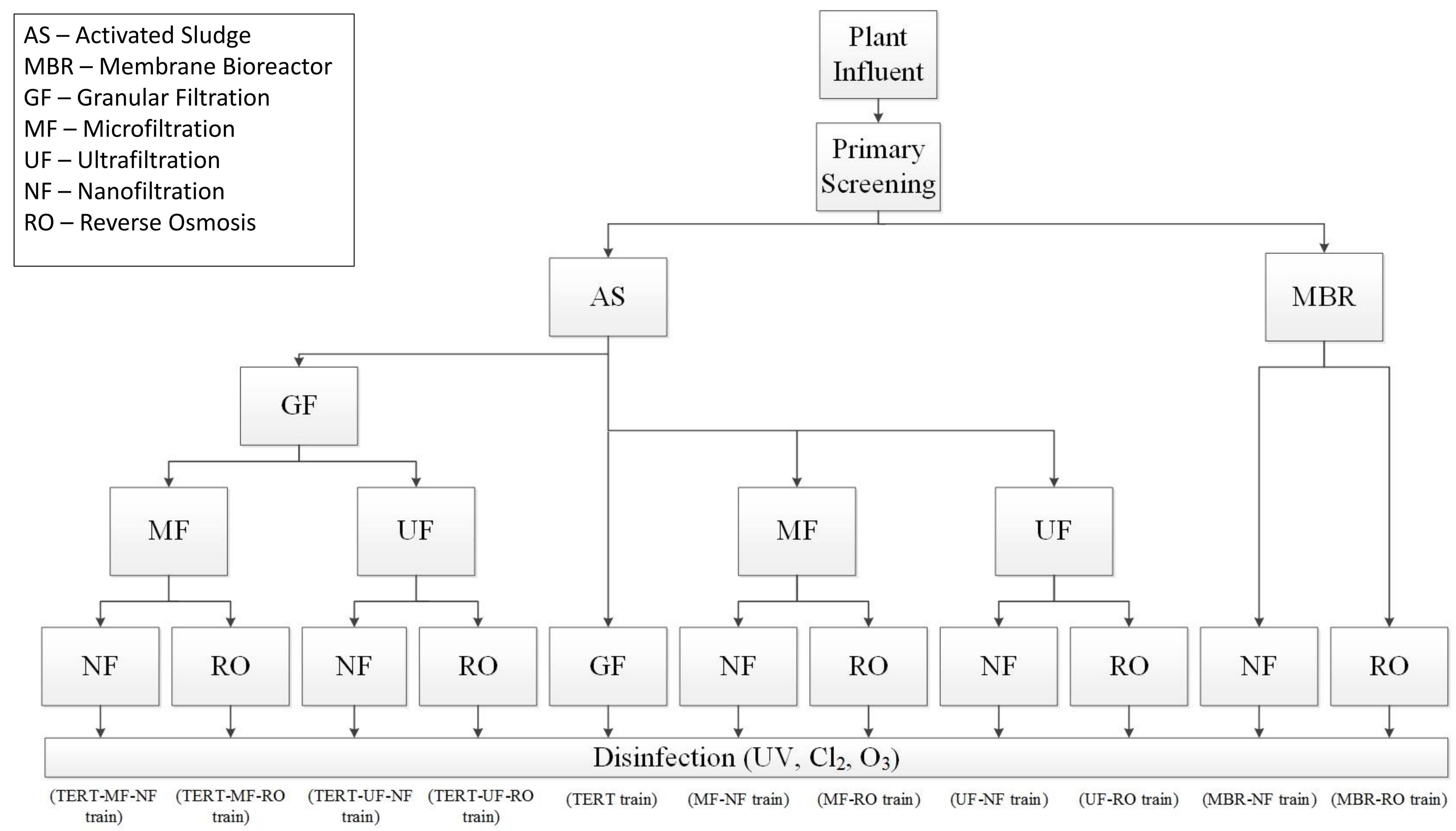


Figure 2. Different treatment train processes corresponding to different GAMS treatment systems

Results

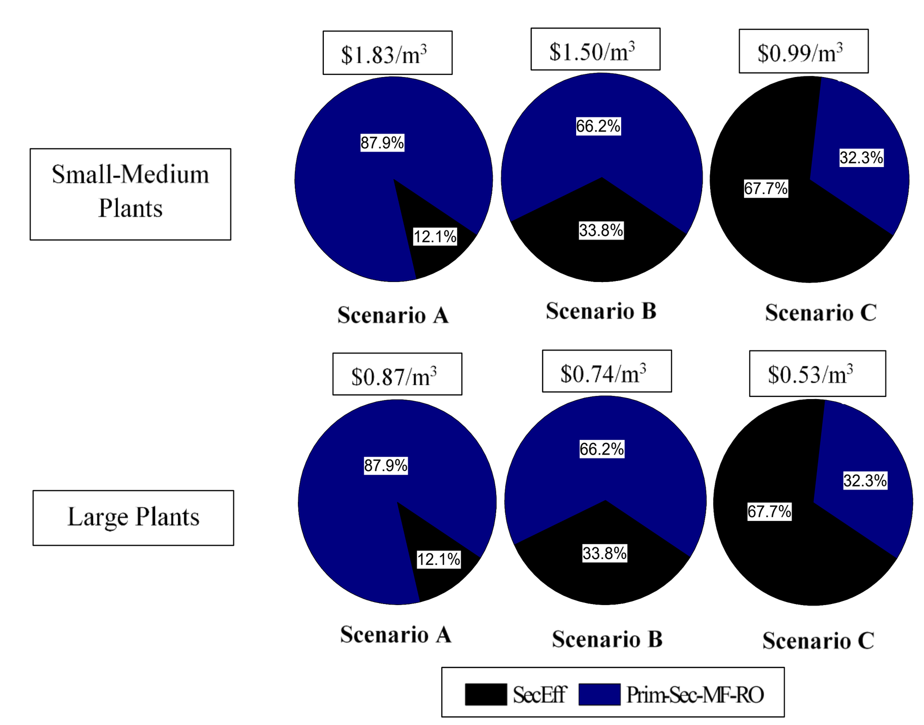


Figure 3. Cost-effective solutions for Citrus

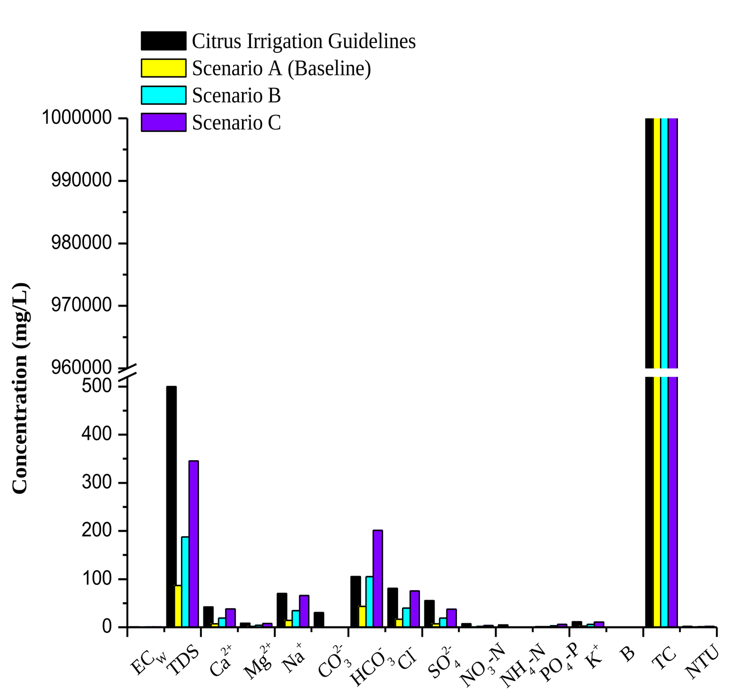


Figure 4. Crop Irrigation guidelines vs. Optimal irrigation quality for citrus

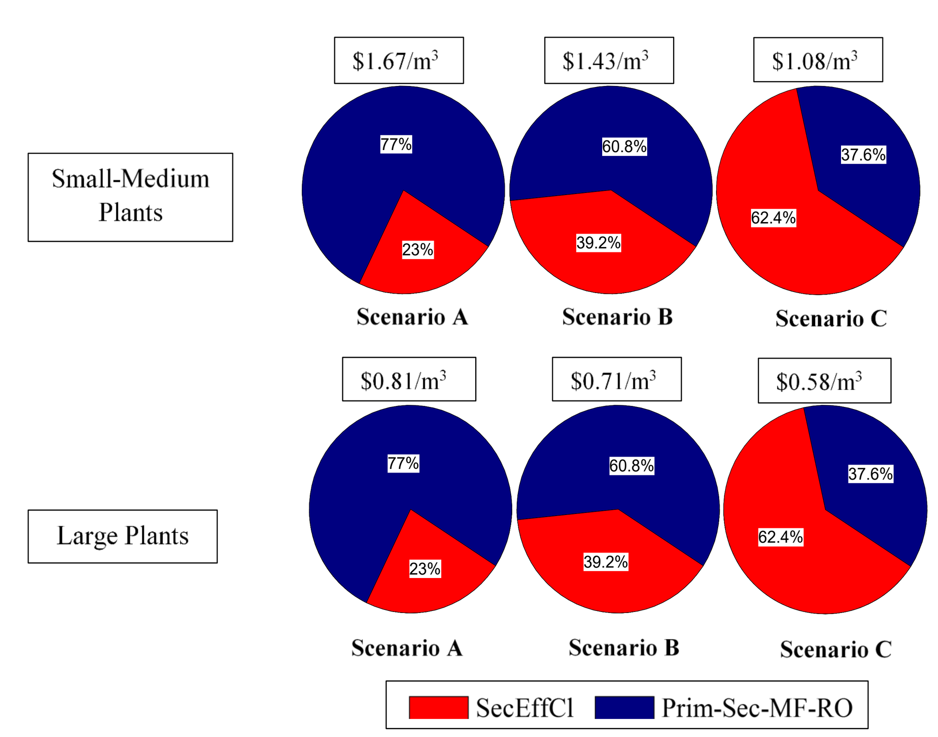


Figure 5. Cost-effective solutions for turfgrass (restricted access)

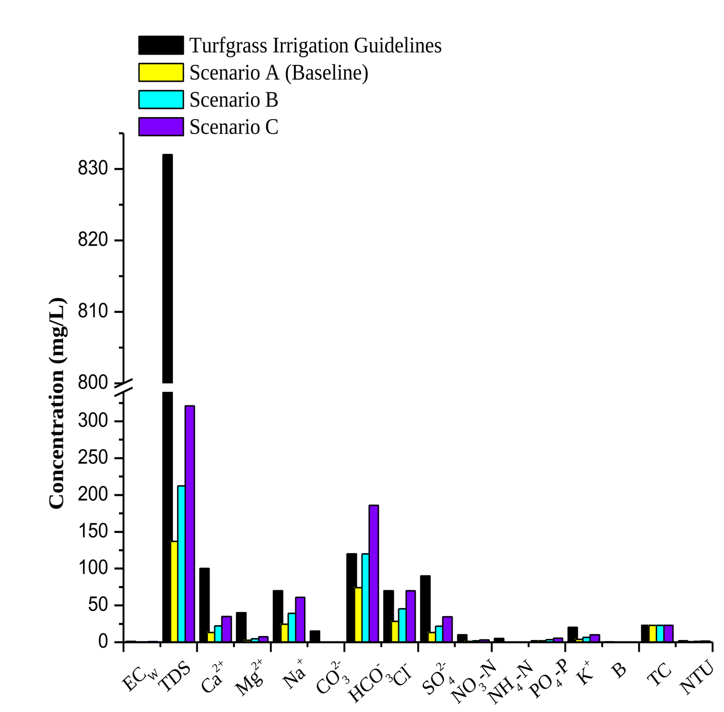


Figure 6. Crop Irrigation guidelines vs. Optimal irrigation quality for turfgrass (restricted access)

Nutrients

Table 1. Nutrients supplied

	Citrus				Turfgrass			
	Nutrients supplied via…							
	Synthetic Fertilizer Alone (kg/ha-yr)	Blended wastewater under… Scenario A (kg/ha-yr)	Scenario B (kg/ha-yr)	Scenario C (kg/ha-yr)	Synthetic Fertilizer Alone (kg/ha-yr)	Blended wastewater under… Scenario A (kg/ha-yr)	Scenario B (kg/ha-yr)	Scenario C (kg/ha-yr)
N	100-400	0.88	1.32	2.00	98-195	1.37	2.20	3.12
P_2O_5	0-228*	33.1	87.2**	172**	49+	120**	201**	317**
K_2O	135-224	37.5	90.8	174	146	128	208*	642*

Table 2. Cost saving on synthetic fertilizer

	Citrus				Turfgrass			
	Costs from Synthetic Fertilizer Alone ($/ha-yr)	Synthetic fertilizer cost savings under… Scenario A ($/ha-yr)	Scenario B ($/ha-yr)	Scenario C ($/ha-yr)	Costs from Synthetic Fertilizer Alone ($/ha-yr)	Synthetic fertilizer cost savings under… Scenario A ($/ha-yr)	Scenario B ($/ha-yr)	Scenario C ($/ha-yr)
N	343.97	0.76	1.14	1.73	168.75	1.18	1.90	2.70
P_2O_5	270.88*	39.48	104.14**	204.96**	58.29	143.35**	239.67**	378.25**
K_2O	163.09	26.91	65.13	124.65	105.04+	91.96	148.82**	230.62**
Total Value (Cost) per ha-yr	(777.94)	67.15	170.41	331.34	(332.08)	236.49	390.39	611.57

Conclusions

- RWRM optimized blending combinations across different treated municipal wastewater effluents with the lowest cost from the MF-RO train
  - The most cost-effective irrigation solution was found without crop nutrients and bicarbonate constraints
  - The driving force behind the high costs and lower nutrient concentration outcomes was RO fraction
  - Scenario C offered maximum cost saving on synthetic fertilizers

Future Work

- Effect of drought on the quality of the discharge effluents from wastewater treatment plants into streams and groundwater systems
- Impacts of drought on agricultural production
- Design efficient wastewater treatment processes based on the characteristics of demand and provide low-cost reliable water within urban scarce water environments

Acknowledgements

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