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Survey of Physical, Chemical, and Microbial Water Quality in Greenhouse and Nursery Irrigation Water

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SUMMARY. The objective was to analyze the physical, chemical, and biological water quality in horticulture irrigation systems in 24 ornamental plant greenhouses and nurseries in the United States. At each greenhouse or nursery, water was collected from up to five points ("Sample Types") which included 1) "Source" from municipal or private well supplies, 2) "Tank" from enclosed storage containers, 3) "Subirrigation" from water applied to crops in ebb-and-flood systems, 4) "Furthest Outlet" that were irrigation emitters most distant from the Source, and 5) "Catchment Basin" from open outdoor retention areas. On average, Source water had the highest physical and microbial quality of Sample Types including the highest ultraviolet (UV) light transmission at 86%, lowest total suspended solids (TSS) at 3.1 mg·L^{-1}, and lowest density of aerobic bacteria with 1108 cfu/mL of water. Average quality of recycled water from Subirrigation or Catchment Basins did not meet recommended levels for horticultural irrigation water for UV transmission (68% to 72% compared with recommended 75%), microbial counts (>100,000 cfu/mL compared with recommended <10,000 cfu/mL), and chemical oxygen demand (COD) (48.2 to 61.3 mg·L^{-1} compared with recommended <30 mg·L^{-1}). Irrigation water stored in Tanks or applied at Furthest Outlets had lower physical and biological water quality compared with Source water. Level of aerobic bacteria counts highlighted a risk of clogged microirrigation emitters from microbial contaminants, with highest bacteria levels in recirculated irrigation water. The physical, chemical, and microbial water quality results indicate a need for more effective water treatment to improve biological water quality, particularly with recirculated irrigation.

Horticultural operations are increasingly using recirculating subirrigation systems and runoff water collected in catchment basins to supplement decreasingly available potable water sources for irrigation (Obreza et al., 2010). Irrigation water that is collected for use in catchment basins (capture-and-reuse) or recirculating (ebb and flood) irrigation systems are characterized by elevated levels of physical, chemical, and biological contaminants that result in lower water quality, compared with potable water (Gilbert et al., 1980; Runia , 1994). When irrigating with low quality water, the combined physical, chemical, and microbial variables can result in microirrigation emitter and filter clogging and promote biofilm formation on critical surfaces within the water distribution systems (Bucks et al., 1979; Ravina et al., 1997). A report by Hong and Moorman (2005) compiled research that identified 16 species of *Phytophthora* (including the plant pathogen *Phytophthora ramorum*), 26 species of *Pythium*, 10 viruses, waterborne plant pathogens, and other microorganisms in irrigation water samples collected from nursery and greenhouse operations.

Sanitation technologies are incorporated into horticulture irrigation systems to provide control of pathogens, improve plant health and prevent the development of secondary inoculum or protective overwintering structures (Agrios, 1997). These technologies include filtration, chlorination, copper ionization, ozonation, UV light, use of activated peroxygens, chlorine dioxide, heat, or other technologies to provide disinfestation of irrigation water (van Os, 2009). Water quality variables such as suspended particles, dissolved organic and inorganic molecules, and microbes create a demand on sanitizing agent active ingredients, thereby reducing the efficacy of water treatment technologies for control of microbes, pathogens, and algae (Copes et al., 2004; Ravina et al., 1997; Sutton et al., 2006).

Monitoring of biological, physical, and chemical variables is necessary to ensure water quality is adequate for its intended use. For example, a standard evaluation for health and operational safety at food and beverage processing and recreational swimming facilities monitors biological variables such as counts of aerobic bacteria and fungi to indicate contamination or ineffective treatment [American Public Health Association (APHA), 1995; Maier et al., 2009]. The reduction of bacterial counts from water samples collected before vs. after water treatment is used as a measure of effective control by a sanitizing agent, according to the U.S. Environmental Protection Agency (USEPA, 1999). Physical

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
1	micron	µm	1
1000	mmho/cm	µS·cm^{-1}	0.0010
1	ppm	mg·L^{-1}	1
6.8948	psi	kPa	0.1450
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32