# Evaluating Water Quality for Ornamental Plant Production

Fact Sheet FS893

## Cooperative Extension

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Water quality plays a crucial role in the successful production of ornamental crops, determining which crops, if any, can be grown, and how irrigation and fertilization must be managed. A thorough water analysis and evaluation must precede any decision to purchase property or take on any ornamental plant production operation. The following are some basic concepts and guidelines that every grower should know about irrigation water quality.

## Chemical Constituents of Water and Their Effect on Plant Growth and Quality

In nature, water is never pure, containing other chemical compounds. Being a "universal solvent," water dissolves a little of most things with which it comes in contact. As it is, many plants respond satisfactorily to irrigation waters of relatively wide-ranging chemical composition. On the other hand, there are plants that are particularly sensitive to specific water quality parameters. Those chemical constituents and properties of water that are important for most plants, and that are required for any meaningful horticultural evaluation, are listed in Table 1.

**Table 1. Chemical properties and constituents of irrigation waters needed for horticultural evaluation.**

| Cations and anions are typically reported in mg/L (same as ppm) or meq/L (milliequivalents per liter). To convert mg/L to meq/L, divide the mg/L of the cation or anion by its respective equivalent weight. | | | | | |
|---|---|---|---|---|---|
| pH = Reported in standard units (between 0 and 14)<br>Electrical Conductivity (EC) = Reported in mmhos/cm (same as mS/cm and dS/m)<br>Alkalinity (as $CaCO_3$ equivalents) = Reported in mg/L or meq/L | | | | | |
| **CATIONS** | **Symbol** | **Equivalent Weight** | **ANIONS** | **Symbol** | **Equivalent Weight** |
| Calcium | Ca | 20 | Chloride | Cl | 35.5 |
| Magnesium | Mg | 12 | Sulfate | $SO_4$ | 48 |
| Sodium | Na | 23 | Bicarbonate | $HCO_3$ | 61 |
| Aluminum | Al | 9 | Carbonate | $CO_3$ | 30 |
| Potassium | K | 39 | Phosphate | $H_2PO_4$ | 97 |
| Ammonium | $NH_4$ | 18 | Nitrate | $NO_3$ | 62 |
| Iron | Fe | Reported as Fe in mg/L | Floride | F | Reported as F in mg/L |
| | | | Borate | $B(OH)_3$ | Reported as B in mg/L |

The following irrigation water properties and constituents are those of greatest concern in ornamental plant production. Refer to Table 2 for specific guidelines for each component.

## Total Soluble Salts

Sometimes also referred to as total dissolved solids (TDS), the total concentration of salts dissolved in water, or salinity, directly affects plant growth by either a specific ion toxicity or as a general salinity effect by reducing the availability of water to the plant. High salt concentrations are known to reduce growth and quality of most crops, although several ornamental plants, like azaleas, are adversely affected by even a mild salinity. Sometimes, plant growth reduction caused by salinity is so subtle as to go unnoticed by growers. The most practical way to measure water salinity is by electrical conductivity (EC). The ability of water to conduct an electrical current is directly related to the concentration of salts present in solution. Thus, the higher the ability of a water to conduct electricity, the higher its salt content, and the less desirable it becomes for plant growth. Electrical conductivity is reported in millimhos per centimeter (mmhos/cm), millisiemens per centimeter (mS/cm), or in decisiemens per meter (dS/m), all of which are equivalent units. As a general rule, irrigation waters are considered to have a high salinity hazard when they have an EC greater than 1.0 mmhos/cm (see Table 2 for water quality guidelines). It should be noted, however, that plant sensitivity to salinity varies with the species. Refer to RCE fact sheet FS663 for a listing of some ornamental trees and shrubs according to their salt tolerance.

**Table 2. Guidelines for interpretation of irrigation water quality. While this information may apply to many crops, it is intended for ornamental species. Evaluation and interpretation of specific water quality problems must always include species, environmental variables, cultural practices and local experience.***

| | Relative Hazard | |
|---|---|---|
| **Type of Problem** | **None to Negligible** | **Moderate to High** |
| **Salinity**: | | |
| EC (mmhos/cm or dS/m) | less than 0.5 | 0.75–3.0 |
| **Permeability**: | | |
| Sodium Adsorption Ratio (SAR, unitless) | less than 3.0 | 6.0–9.0 |
| **Ion toxicity due to root and/or foliar absorption:** | | |
| Boron (mg/L) | 0.3–0.5 | 0.5–2.0 |
| Chloride (mg/L) | less than 110 | 140–360 |
| Fluoride (mg/L) | less than 1.0 | more than 1.0 |
| Sodium (mg/L) | less than 70 | 70–210 |
| **Unsightly foliar deposits:** | | |
| Bicarbonate (mg/L) | less than 120 | 180–360 |
| Iron (mg/L) | less than 1.0 | more than 1.0 |
| Manganese (mg/L) | less than 1.0 | more than 1.0 |
| **Soil pH maintenance:** | | |
| Alkalinity (as mg/L CaCO3) | 60–120 | 180–360 |
| pH (Standard units) | 5.0–8.0 | more than 8.0 |

* Table adapted from Water Quality: Its Effects on Ornamental Plants, University of California Cooperative Extension Leaflet No. 2995 (1985).

## pH and Alkalinity

In soils and other growing media, pH is an important chemical property related to plant growth, particularly for its effect on nutrient availability. As such, its monitoring and control is emphasized in crop management. On the other hand, and contrary to common wisdom, the pH of water is by itself a parameter that is often inconsequential during production. The normal pH range for most irrigation waters is between 5 and 8, with values above 7 considered undesirable. It is, however, the relationship between water pH and alkalinity, namely the presence of high alkalinity that will have a more significant impact on pH control of soils and growing media. Alkalinity is a measure of the water's capacity to neutralize acids, and it establishes the buffering capacity of water. Buffering is a term used to describe how resistant a solution is to changes in pH. The greater the alkalinity of a water, the more "fixed," or stable, its pH becomes, and the more acid will be required to lower it. If no acid is used to neutralize the high alkalinity water, over time it will significantly elevate the growing medium pH to undesirable levels, causing reductions in plant growth and quality. Alkalinity is typically expressed in units of concentration of calcium carbonate ($CaCO_3$) equivalents, either in mg/L or meq/L (for $CaCO_3$ unit conversion: 1 meq/L = 50.04 mg/L). Some laboratories also express alkalinity in mg/L of bicarbonate ($HCO_3$). To convert to meq/ L $CaCO_3$, divide mg/L of bicarbonate by 61. Although information on alkalinity levels for nursery crops (i.e., woody ornamentals) is vague, 60–120 mg/L $CaCO_3$ could be used as an adequate guideline. Acid injection will likely be required for waters with alkalinity levels in excess of 180–240 mg/L $CaCO_3$. This will require professional consultation and installation of equipment by laboratories or companies specializing in water testing and irrigation systems.

## Chloride ($Cl^-$)

When absorbed by plant roots, chloride is transported to leaves, where it accumulates. This accumulation produces undesirable, and damaging symptoms that include leaf necrosis (often observed as marginal scorching) and leaf abscission. Woody species like camellias, rhododendrons, roses, and stone fruits are particularly sensitive to chloride toxicity. Symptoms are first expressed in older foliage. In addition to absorption by roots, the application of high chloride content waters through overhead sprinklers may also result in its absorption by the foliage, which, upon reaching toxic levels, often cause leaf abscission. In general, waters with chloride concentrations in excess of 100 mg/L should be carefully considered, as the growth and quality of many sensitive woody ornamentals will likely be affected.

## Sodium ($Na^+$)

Plant roots can also absorb sodium and transport it to leaf tissue where it accumulates. Sodium toxicity symptoms are similar in appearance to those of chloride toxicity, namely marginal scorch on older leaves. Foliar absorption of sodium applied by overhead sprinkler irrigation also produces the same toxic effects as chloride. Use of waters with sodium concentrations higher than 70 mg/L could begin to adversely affect the growth and quality of many ornamental crops.

## Boron (B)

Although boron is an essential requirement for plant growth, relatively low concentrations in water are quite toxic to most ornamental species. As little as 0.5 mg/L can result in undesirable leaf-margin necrosis. Boron accumulation in leaves is mostly caused by root absorption, but unlike chloride and sodium, water applied to leaves by overhead sprinkler irrigation do not readily absorb boron.

## Calcium ($Ca^{++}$) and Magnesium ($Mg^{++}$)

These two elements are essential for plant growth and their concentration in most irrigation waters is seldom high enough to cause salinity problems. While there are no acceptable limits for these elements, their determination is important because their concentrations are used in the calculation of the critically important parameter sodium adsorption ratio (SAR). Furthermore, the presence of high calcium and magnesium concentrations implies a hard water condition, and could produce unsightly precipitates on leaves with sprinkler irrigation, and clog irrigation-related equipment.

## Sodium Adsorption Ratio (SAR)

This is a calculated value that indicates the relationship of the irrigation water's sodium content to its combined calcium and magnesium. The SAR values help to determine the potential for permeability problems in mineral (field) soils, as well as the possibility for plant sodium toxicity after long-term use of the water. The following formula is used to calculate SAR for water (using meq/L units): SAR = [Na] / SQRT (( [Ca] + [Mg] )/2). Waters with SAR values below 3 are considered ideal, while values higher than 6 could adversely affect the permeability of field soils and in¬crease foliar and root absorption to the point of causing severe leaf burn and abscission. A nomogram that quickly allows one to determine the SAR can be found in chapter 5; page 73 at ars.usda.gov/News/docs.htm?docid=10158&page=2.

### Bicarbonate ($HCO_3^-$) and Carbonate ($CO_3^-$)

These two substances constitute the previously described term alkalinity. Carbonate is typically found in very low concentrations, and thus seldom reported. Bicarbonate per se is not a toxic ion, but it can cause significant increases in medium pH. As the soil or medium dries out, calcium and magnesium combine with bicarbonate and carbonate to form fairly insoluble salts. These salts are basically what we know as lime, and their pH-raising effect is more rapid in containers and greenhouse bench soils than in field soils. Furthermore, overhead sprinkler application of waters with high bicarbonate, in conjunction with high calcium and magnesium concentrations, will form unsightly precipitates on leaves. Beware that the use of water softeners (typically sodium bicar¬bonate) will raise the concentration of sodium and bicarbonate, a combination that will cause serious problems for plants. Prolonged use of water with bicarbonate concentrations exceeding 120 mg/L will likely cause problems with medium pH and foliar deposits.

### Iron ($Fe^{++}$ and $Fe^{+++}$)

Deficiencies of this essential plant element are fairly common in production, mostly the cause of low availability resulting from high medium pH. Certain irrigation waters, however, naturally contain high iron concentrations that in fact can produce unsightly rust, brown or blackish deposits on foliage following overhead irrigation. A similar situation can also occur with manganese. These unsightly foliar deposits are due to the precipitation of iron compounds oxidized following ex¬posure to air. Iron concentrations higher than 1 mg/L will likely give rise to this problem.

### Fluoride (F)

When present in concentrations over 1 mg/L, this element can cause severe tip burn and scorch in plants like foliage plants and Easter lilies. While fluorinated municipal waters rarely exceed this concentration, beware that some irrigation waters contain much higher, and harmful, concentrations.

## Water Sampling

A reliable assessment of water quality depends not only on the precision and accuracy of the analytical procedures used by a laboratory, but on how representative is the water sample provided for analysis. Consequently, water sampling and handling, operations typically carried out by growers, deserve particular attention and care. Many laboratories, upon request, will provide water-sampling kits that include appropriate containers and instructions on how to collect and handle representative samples. In general terms, the procedure calls for the taking of samples as close as possible to the well or main pump, and only after the upstream piping has been purged of standing water. The use of a portable EC meter would be very valuable in ensuring the collection of representative samples from the source, namely once stable EC readings are observed after the irrigation system has been operating for some time. Place the sample, most laboratories request one pint (500 mL), in an inert container, preferably made out of plastic and that has not been used to store chemicals like fertilizers or pesticides. Avoid glass and metal containers, as they will likely contaminate the water with elements of interest like boron and iron. Ship the sample as soon as possible after collection to the laboratory.

## Evaluating and Interpreting Your Water Analysis Results

Besides listing of concentrations and units found for the water constituents analyzed, most laboratory reports will provide some indication of potential problems with specific constituents. This is, however, often limited to ratings from generic scales like low to high, or above and below normal. Some basic guidelines are presented in Table 2 with the intention of better assisting growers to determine the suitability of, and troubleshoot some common problems associated with, waters used to irrigate ornamental crops. It must be kept in mind, however, that evaluation and interpretation of specific water quality problems and their severity should include crop species, growing medium or soil, environmental variables and local experience. Should you suspect problems with your water, need help finding a reputable laboratory, need assistance interpreting your water analyses reports, and/or need recommendations to deal with specific water quality problems, contact your county Rutgers Cooperative Extension office.

## References

The following are some of the most useful references that contain a good deal of information and recommendations on water quality, all specifically geared toward ornamental plant production. Furthermore, these references also cover the closely related topics of growing media and fertilization.

Bunt, A.C. 1988. Media and Mixes for Container-Grown Plants. Unwin-Hyman Publishing. 309 pp. David, W. Reed (Editor). 1996. A Grower's Guide to Water, Media and Nutrition for Greenhouse Crops.

Ball Publishing. 314 pp.

Farnham, D.S., Hasek, R.F. and Paul, J.L. 1985. Water Quality: Its Effects on Ornamental Plants. Univer¬sity of California Cooperative Extension Leaflet No. 2995. 15 pp.

Handreck, K.A. and Black, N.D. 1994. Growing Media for Ornamental Plants and Turf. University of New South Wales Press. 448 pp.



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