On-Site Water Quality Testing

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Every river basin in Colorado has risen above the 30-year average when it comes to snowpack and experts say the state appears to be bouncing back from a five-year drought.

*Robert Weller, The Associated Press*
*Denver Post 5 January 2005*

However; “If Congress had listened to explorer and scientist John Wesley Powell 125 years ago, the American West today might be an entirely different place.”

*Howard Berkes, NPR 26 Aug 2003*
Greenhouses and nurseries get their water from three sources:
- Agricultural wells
- Surface irrigation canals or reservoirs
- Municipal providers

Quality is an issue regardless of the source:
- Alkalinity
- Salinity
- pH
- Sodium Absorption Ratio
- Specific Ions
- Suspended Solids
- Sanitation
Water quality testing on site can be convenient and immediate with the right tools:

- Alkalinity
- Salinity
- pH
- SAR
- Specific Ions
- Solids
- Sanitation
Effect of Water Alkalinity on Substrate pH

**Sample A**

- $pH = 9$
- $alk = 50$
- Little or no effect on medium $pH$
- 1 drop of acid to get $pH 6$

**Sample B**

- $pH = 7$
- $alk = 300$
- Increases substrate $pH$
- 10 drops of acid to get $pH 6$
Key to Alkalinity Issues

- Alkalinity is crop dependent
  - Range of 40 to 120 ppm CaCO$_3$ is recommended
  - 40% of US greenhouse irrigation water > 200 ppm
  - 18% of US greenhouse irrigation water < 40 ppm
- There is really no single optimal alkalinity
  - *The key is to adapt your nutrient management practices to your water source*
Measuring Alkalinity

- Commercial laboratories
- In-house
  - Titration kits
  - Colorimetric kits
  - Test strips
Water Salinity

- Total dissolved solids
- Measured by electrical conductivity
  - Determined by passing a current through the solution and determining its electrical conductance
  - Units are millimhos/cm, or
decisiemens/meter (dS/m)
Water Salinity

- Restrictions to use:
  - < 0.25 dS/m  None
  - 0.25-0.75 dS/m  Moderate
  - 0.75-2.25 dS/m  High
  - > 2.26 dS/m  Severe

- Multiply by 700 to convert to ppm TDS
  - Total Dissolved Solids
A pH reading is a measurement of the hydrogen ion concentration of a solution:
- 0 most acid to 10 most basic
- pH = 7 is neutral
- The relative number of hydrogen and hydroxide ions

- pH = 5.4 to 7.0 acceptable for most crops

\[
\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^- \\
pH = \frac{1}{[\text{H}^+]} 
\]
Ions

- Cation - an ion with a positive charge
  - Ca^{++}  Mg^{++}  H^{+}  K^{+}  NH_{4}^{+}
- Anion - an ion with a negative charge
  - OH^{-}  NO_{3}^{-}  SO_{4}^{2-}  Cl^{-}

Charges must be balanced in solution
pH and Water Chemistry

Battery acid
Vinegar
Orange juice
Deionized water
Baking soda
Ammonia
Bleach
Lye

Acid
Neutral
Alkaline
Plants grow best at a pH of 7, which is Neutral. Acidic conditions (pH < 7) and Alkaline conditions (pH > 7) are less favorable for plant growth.
pH Meters
Calibrate your pH Meter
Irrigation water is often overlooked as a source of infection.
Irrigation Water Disinfection

- UV-C Sterilization
- Heat Treatment
- Chlorination
- Ozone Treatment
- Hydrogen Peroxide

On-site Testing
Oxidation Reduction

**Oxidation** is defined as an increase in the positive oxidation number with a corresponding loss of electrons.

**Reduction** is a decrease in the positive number of ions with a corresponding gain in electrons.

Reduced compound A (reducing agent)

Oxidized compound B (oxidizing agent)

A is oxidized, losing electrons

B is reduced, gaining electrons

Oxidized compound A

Reduced compound B
## Common industrial oxidizers and their potential relative to chlorine

<table>
<thead>
<tr>
<th>Oxidant</th>
<th>Oxidation potential (mV)</th>
<th>Oxidation relative to chlorine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorine</td>
<td>3,050</td>
<td>2.25</td>
</tr>
<tr>
<td>Ozone</td>
<td>2,070</td>
<td>1.52</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>1,780</td>
<td>1.31</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>1,680</td>
<td>1.25</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>1,570</td>
<td>1.15</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1,360</td>
<td>1.00</td>
</tr>
<tr>
<td>Bromine</td>
<td>1,070</td>
<td>0.70</td>
</tr>
</tbody>
</table>
### Pathogen survival from laboratory simulations and hydrocooler studies according to Suslow (2003)

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival at ORP (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 485</td>
</tr>
<tr>
<td><strong>E. coli O157:H7</strong></td>
<td>&gt; 300 s</td>
</tr>
<tr>
<td><strong>Salmonella spp.</strong></td>
<td>&gt; 300 s</td>
</tr>
<tr>
<td><strong>L. monocytogenes</strong></td>
<td>&gt; 300 s</td>
</tr>
<tr>
<td>Thermotolerant coliform</td>
<td>&gt; 48 hr</td>
</tr>
</tbody>
</table>
Oxidation Reduction and $\text{pH}$

![Graph showing the relationship between oxidation reduction potential (mV) and solution pH.](image)

- Oxidation reduction potential (mV)
- Solution pH
- $\text{OCl}^-$
- $\text{pH}$
- $\text{HOCl}$
Oxidation Reduction and $pH$

Regal geranium stock plants

Hypochlorous acid injected into irrigation water
Oxidation Reduction and Cl

Colorado Greenhouse Example

With acid injection
ORP=825 mV
Free Cl=1.4
Total Cl=2.25
ORP Measurement and Chlorine

Panel Mount with Installed ORP Electrode

Handheld ORP Meter

Free Chlorine

$135-$150
Colorimetric Chlorine
Colorimetric Chlorine
Other Chlorine Tests

ORP Indicator Strips

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Resources

Publications

- Water, Media and Nutrition, edited by D.W. Reed. Ball Publishing
- Understanding pH Management for Container-grown Crops, W.R. Argo and P.R. Fisher, Ball Publishing

Extension Publications

- Alkalinity control for irrigation water used in nurseries and greenhouses. D. Bailey and T. Bilderback. Horticulture Information Leaflet 558, NCSU.
- Water considerations for container production of plants. D. Bailey, T. Bilderback and D. Bir. Horticulture Information Leaflet 557, NCSU

- These three Extension publications, as well as others, can be downloaded free from the NCSU Extension Floriculture Website at:
  - http://www.ces.ncsu.edu/depts/hort/floriculture/crop/crop_water.htm
Resources

- **Hach Laboratories**

- **Pulse Instruments**
  - [http://www.pulseinstruments.net/](http://www.pulseinstruments.net/)

- **Hanna Instruments**
  - [http://www.hannainst.com/usa/](http://www.hannainst.com/usa/)

- **Oakton Instruments**
  - [http://www.4oakton.com/](http://www.4oakton.com/)

- **Spectrum Technologies**
  - [http://www.specmeters.com/](http://www.specmeters.com/)