

WATER QUALITY

PLANT HEALTH FACTORS



Water quality is one of the most important factors affecting plant growth, as unwanted components in water can interfere with nutrient availability and uptake by the plant. When improving your grow operation, water should be one of the key areas evaluated. Even with a filter in place, problems may still arise if quality is not closely monitored. In this paper, we will discuss the steps you should take to evaluate your water, what issues might be present, factors affecting water quality and troubleshooting solutions.

FACTORS AFFECTING WATER QUALITY

Water Source: Municipal vs. Private Well: All natural water sources will contain some levels of dissolved salts and trace minerals. The source of the irrigation water can drastically change the levels of salts and minerals found in water. Excessive amounts of mineral salts found in water can have a negative effect on plant health (see images) due to nutrient antagonism (Appendix B).

Untreated well water may contain high levels of fertilizer salts as a result of runoff, sediment, and calcium from water hardness. Municipal water sources may be treated with chlorine or chloramine to kill pathogens, but this can have a detrimental effect on plant health. This water source may also have high levels of sodium or potassium as a result of water softening agents used to reduce water hardness. Heavy metals occur naturally in the environment and can be found in private and municipal water sources. Many of these have the potential to accumulate to toxic levels in soil and plant tissues.

Waterborne pathogenic organisms may exist naturally or appear as a result of fecal contamination from livestock. These include viruses, fungi and bacteria such as *E. coli* and salmonella. Some pathogenic organisms may not have a direct impact on plant health but can most certainly affect the humans working with plants. Some waterborne organisms do have a direct effect on plant health, such as nematodes, *Pythium* and *Phytophthora*.



Damping off caused by *Pythium fungus*



Sulfur deficiency in alfalfa



Magnesium deficiency in grape



Calcium deficiency in sugarbeet



Potassium deficiency in soybeans

WATER QUALITY CHECKLIST

1. **Check your pH:** pH is the measure of the concentration of hydrogen (H^+) ions in a solution. Water (H_2O) consists of hydrogen ions and hydroxide (OH^-) ions. Water with a neutral pH of 7.0 has an equal balance of hydrogen and hydroxide ions. The more H^+ ions that exist, the more acidic the solution. The more OH^- ions that exist, the more basic the solution. Water with a pH between 5.5 and 7.0 is an ideal range for horticulture. Once water pH increases beyond neutral, there is an increased risk for limited nutrient availability and solubility. A pH above 8.5 may also have high alkalinity or high total dissolved solids (TDS), meaning that levels of

carbonates or salts are elevated, further contributing to limited nutrient uptake. Water with a pH below 5.5 may have an excess of hydrogen ions and a decreased buffering capacity.

2. **Check your EC or TDS:** EC is a measure of electrical conductivity in water, and TDS is a measure of total dissolved solids in a solution. EC and TDS are not the same unit of measure, but are closely related and either one can be used to determine water hardness.

Most EC meters will convert to ppm on either a 500 or a 700 scale, so it is important to note which scale your meter is converting from. If EC or TDS is above the desired range, filtration is the best option to reduce the amount of salts in the water.

Although most horticulture research recommends a TDS below 640 ppm for best results, hydroponic and soilless cannabis cultivation tends to show higher sensitivity to pH fluctuation and salt buildup when TDS is above 200 ppm (500 scale) or 0.4 EC.

3. **Order a Water Test:** Collect a water sample according to directions and submit to a qualified water analysis laboratory. Universities are a great resource for this, as many have agriculture extension programs that work exclusively with farmers. They will also provide irrigation water analysis, which will contain much more relevant information than a drinking water analysis. This is the most accurate method to determine the quality of your water and what factors may affect plant health and performance. See below for an example of a water analysis report.

WATER QUALITY ANALYSIS

The following report from Penn State Water Quality Extension shows high pH, bicarbonate alkalinity and hardness. Alkalinity has a direct correlation with elevated soil pH values and reduced micronutrient uptake. Alkalinity in water should not be confused with an alkaline, or basic, pH. In terms of water quality analysis, alkalinity refers to the content of bicarbonates or carbonates in the water and the buffering capacity that provides.

When bicarbonates or carbonates are in excess, they form insoluble complexes from magnesium and calcium, causing sodium to become the dominant ion in the water. This leads to a lack of available calcium and magnesium to the plant and interferes with water uptake by the roots. As the plant removes minerals from the solution and as moisture evaporates, those insoluble complexes can also accumulate in soil and clog irrigation equipment. High pH is also more likely to accumulate soluble salts in the growing medium, further interfering with nutrient uptake and causing unpredictable pH fluctuations.

WATER ANALYSIS
Irrigation Water Report (WH02)

Analysis	Result	Units	Level of concern
pH	7.9	-	Below 5.0 or above 7.0
Total Alkalinity as CaCO ₃	108.4	mg/L	Below 30 or above 100
Bicarbonate (HCO ₃) Alkalinity	132.3	mg/L	-
Carbonate (CO ₃) Alkalinity	0.0	mg/L	-
Hardness as CaCO ₃	222.1	mg/L	Below 50 or above 150
Electrical Conductivity (EC)	0.49	mmhos/cm	Above 1.0 for plugs or above 1.5 for others
Total Dissolved Solids (TDS)	311.9	mg/L	Above 640 for plugs/seedlings or above 960 for others
Nitrate-Nitrogen (NO ₃ -N)	0.3	mg/L	Consider in overall fertility program
Ammonium-Nitrogen (NH ₄ -N)	< 1.02	mg/L	Consider in overall fertility program
Phosphorus (P)	0.05	mg/L	Above 5.0 may cause micronutrient deficiencies
Potassium (K)	3.13	mg/L	Consider in overall fertility program
Calcium (Ca)	62.63	mg/L	Below 40 or above 100
Magnesium (Mg)	15.96	mg/L	Below 25
Iron (Fe)	< 0.10	mg/L	Above 0.30 for micro-irrigation or above 5 for plant toxicity
Manganese (Mn)	< 0.01	mg/L	Above 0.05 for micro-irrigation or above 2 for plant toxicity
Zinc (Zn)	< 0.01	mg/L	Above 0.30 toxic to most plants
Copper (Cu)	< 0.01	mg/L	Above 0.20 toxic to some plants
Boron (B)	0.04	mg/L	Above 0.50 for sensitive plants, above 2 for most plants
Molybdenum (Mo)	< 0.010	mg/L	Above 0.05 toxic to some plants
Sulfur (S)	46.8	mg/L	Below 10 may require addition of S fertilizer
Chloride (Cl)	12.61	mg/L	Above 30 for sensitive plants, above 100 for most plants
Sodium (Na)	20.21	mg/L	Above 50
Sodium Adsorption Ratio (SAR)	0.59	-	Above 2.0

The above results and interpretations are applicable to raw irrigation water used for greenhouse or high tunnel production only. Level of concern for each parameter are general; some plants have water quality tolerances that differ from those listed here. A brief description of each parameter is provided on the back of this report. Additional information about irrigation water quality may be found on the Penn State Water Quality Extension website, <http://extension.psu.edu/natural-resources/water/agriculture>

WATER QUALITY IMPROVEMENTS

Adjust Alkalinity: There are several acids available for horticultural use that are an effective tool to reduce alkalinity of irrigation water.

Table 1. Acids commonly used to acidify irrigation water and their properties.

Acid	Formulation and density (d) or formula weight (FW)	Amount of acid to add for each meq/L of alkalinity to result in a water pH of approximately 5.8*	Concentration of nutrient provided by one fl oz. of acid per 1000 gallons water**	Cost per meq/L per 1000 gal***	Relative safety****
Citric acid (2-Hydroxy-1,2,3-propanetricarboxylic acid) $H_3C_6H_5O_7$	99.5% (w:w) granular FW = 192.1	9.1 oz/1000 gals	none	\$0.59	can cause minor skin and eye irritation
	50% (w:w) liquid d = 1.21	14.5 fl. oz/1000 gals	none	\$0.96	can cause minor skin and eye irritation
Nitric acid H_2NO_3	67% (w:w) liquid d = 1.42	6.6 fl oz/1000 gals	1.64 ppm N	\$0.26	use extreme caution; very caustic and dangerous; avoid contact with fumes as well as acid
Phosphoric acid H_3PO_4	75% (w:w) liquid d = 1.58	8.1 fl oz/1000 gals	2.88 ppm P	\$0.44	slightly caustic; can cause skin and eye irritation as well as damage clothing
Sulfuric acid H_2SO_4	35% (w:w) liquid d = 1.26	11.0 fl oz/1000 gals	1.14 ppm S	\$0.16	slightly caustic; can cause skin and eye irritation as well as damage clothing

*Add this amount for each meq/L of alkalinity present. For example, if your water report indicates an alkalinity of 3 meq/L and you choose to use sulfuric acid, you would add 33 fl oz. of 35% sulfuric acid per 1000 gallons of water (11 fl oz/meq/L \times 3 meq/L = 33 fl oz). Calculations based on the following dissociation values: 2.07 meq H^+ per 3 meq $H_3C_6H_5O_7$, 1 meq H^+ per 1 meq H_2NO_3 , 1.02 meq H^+ per 3 meq H_3PO_4 , and 1 meq H^+ per 1 meq H_2SO_4 .

**In the above example, the acid would supply 38 ppm S at each irrigation (33 fl oz \times 1.14 ppm S/fl oz. = 33 ppm S).

***Acid cost to neutralize 1 meq/L alkalinity per 1000 gallons of water. Based on the following costs: \$1.04/lb of 99.5% citric acid; \$8.45/gal of 50% citric acid; \$5.00/gal of 67% nitric acid; \$7.00/gal of 75% phosphoric acid; \$1.90/gal of 35% sulfuric acid.

****Use caution with ALL acids. Wear eye protection, acid-resistant gloves, and an acid-resistant apron when handling any acid.

Filtration Systems: If there are known pathogens in the water supply, there are several options available to reduce contamination. Chlorine is commonly used in drinking water supplies, but high residuals may have a negative effect on plant health. If high salts or heavy metals are a problem, reverse osmosis filtration is the best solution to produce pure water. Other inexpensive alternatives include acid injections prior to irrigation to neutralize alkalinity and ultraviolet filters to kill unwanted organisms in the water. Table 2 outlines filtration options for various water quality issues.

Table 2. Filtration Options

	Total Dissolved Solids	Bicarbonate & Carbonate	Calcium & Magnesium
Reverse Osmosis	X	X	X
Deionization	X	X	X
Anion Exchange		X	
Water Softening (cation exchange)			X
Acid Injections		X	

CONCLUSION

Aside from pest management, water quality analysis is one of the most important preventative and diagnostic tools available to growers. Prior to using water for irrigation, obtain a detailed analysis from a qualified water testing lab to identify and correct any potential future problems. If plant health appears to be compromised, water quality should always be the first item to check off the troubleshooting list.

Poor water quality can interfere with nutrient availability and uptake, worker health, and plant performance and yield. Paying attention to water quality and taking necessary steps to correct issues will prolong equipment operation, prevent crop losses and ultimately save the grower money and contribute to continued success.

APPENDIX A

Information Resources

Table 1: <https://www.ces.ncsu.edu/depts/hort/floriculture/plugs/alkalinity.pdf>

Acid adjustment calculator: http://extension.unh.edu/Agric/AGGHFL/alk_calc.cfm

<http://www.croptonutrition.com/nutrient-knowledge>

APPENDIX B

EXCESS ELEMENT	NUTRIENT(S) AFFECTED
Nitrogen	Potassium, Calcium
Potassium	Nitrogen, Calcium, Magnesium
Phosphorus	Zinc, Iron, Copper
Calcium	Boron, Magnesium, Phosphorus
Magnesium	Calcium, Potassium
Iron	Manganese
Manganese	Iron, Molybdenum, Magnesium
Copper	Molybdenum, Iron, Manganese, Zinc
Zinc	Iron, Manganese
Molybdenum	Copper, Iron
Sodium	Potassium, Calcium, Magnesium
Aluminum	Phosphorus
Ammonium Ion	Calcium, Copper
Sulfur	Molybdenum