2-2017

How to Collect your Water Sample and Interpret the Results for the Irrigation Analytical Package

Bradley J. Austin
University of Arkansas, Fayetteville

Leo Espinoza
University of Arkansas, Fayetteville

Chris Henry
University of Arkansas, Fayetteville

Mike Daniels
University of Arkansas, Fayetteville

Brian E. Haggard
University of Arkansas, Fayetteville

ARKANSAS WATER
RESOURCES CENTER

How to Collect Your Water Sample and Interpret the Results for the Irrigation Analytical Package

Bradley J. Austin, Leo Espinoza, Chris Henry, Mike Daniels, and Brian E. Haggard
University of Arkansas System Division of Agriculture

FS-2017-03 | February 2017

How to Collect Your Water Sample and Interpret the Results for the Irrigation Analytical Package

Bradley J. Austin, Leo Espinoza, Chris Henry, Mike Daniels, and Brian E. Haggard
Arkansas Water Resources Center
University of Arkansas System Division of Agriculture

Irrigation represents a significant portion of the total production cost for crops. Because of this it is important to have your water tested to ensure that it is suitable for the crops you are growing, and to aid in developing management plans that might help alleviate existing issues such as high salt levels or high alkalinity. The Arkansas Water Resources Center (AWRC) in cooperation with the UA Cooperative Extension Service offers several analytical packages to assess the quality of your water resources. This document is intended to provide guidance to farmers on collecting water samples for analysis and understanding the "Irrigation (All Crops) Water Report Form" and "Irrigation (Drip or Trickle) Water Report Form" provided by the AWRC's Water Quality Laboratory (Lab). The information contained within this fact sheet should be used as general guidance, and the reader is encouraged to seek advice from Extension specialists regarding the interpretation of individual reports and water testing results that may be of concern.

Why Should You Have Your Irrigation Water Tested?

As mentioned earlier, irrigation makes up a significant portion of the total crop production cost. Knowing what is in your irrigation water can help you save money by ensuring you are providing suitable water for your crops to produce the best yields, as well as to help tailor management plans to alleviate existing issues. It can also protect from degrading the productivity of your soils where salts can accumulate or alkalinity can change your soil pH.

The use of drip or trickle irrigation systems can also reduce costs through irrigating crops with less water, decreased cost of pumping water, healthier plants, and decreased cost of weed control just to list a few (Lamont et al. 2012). However, the initial investment of installing drip or trickle irrigation systems are often higher and have the potential to have higher maintenance costs (Lamont et al. 2012), especially if your water source is of poor water quality. Having your irrigation water analyzed can also help you decide which steps you need to take to reduce clogging for your drip irrigation system, which will decrease maintenance costs.

Collection Of Water For Analysis

The AWRC Water Quality Lab requires 0.5 liters (roughly half a quart) to measure all of the parameters included in the irrigation analytical packages. You should properly label a clean sampling bottle with your site information; clean bottles can be obtained from the AWRC Water Quality Lab or your local county Extension office, if needed. If your primary water source is a pond or reservoir, the sample should be collected from the middle of the body of water at roughly one foot below the surface. In streams, water samples should be collected from the area with the fastest moving water, this area is the most thoroughly mixed and representative of the overall stream water quality. If well water is used to irrigate your crops, allow the pump to run for 30 minutes before collecting the water sample, to clear out any stagnant water in the pipes giving you a sample that reflects your water source.

Your sample bottle should field rinsed three times prior to collecting the sample. To do this fill the sample bottle approximately ¼ full, cap and shake, and then discard the rinse water away from the location that you will be collecting your sample. If you have multiple water sources for your irrigation water, each source should be tested separately. When submitting multiple samples, make sure that you properly label your sample bottles so that the samples can be distinguished from one another. Samples being submitted to the AWRC Water Quality Lab should include a completed AGRI-422 form. Samples should kept cool, preferably on ice and out of the sun, and submitted to the AWRC Water Quality Lab as soon as possible. You can reduce delays during shipping by avoiding submitting samples at times when they will reach the laboratory on a holiday or weekend. Because the concentrations of the variables in this analysis package may change over time in unpreserved water samples, it is important for the samples to arrive at the lab as soon as possible.

For the most reliable results, water samples should be kept cool, in the dark, and delivered to the AWRC Water Quality Lab as soon as possible.

Interpreting Results

Table 1 provides a list of acceptable concentrations for each of the parameters analyzed in the irrigation water quality analytical packages. It summarizes data based on what is acceptable for crop irrigation as well as acceptable levels needed to keep drip irrigations systems free from clogs. Concentrations and values within the range of moderate to high level of concern should be considered for corrective actions (Table 1). In the descriptions below, specific holding times are listed for each parameter. Many of the parameters are stable for 14 days to 6 months once they have been filtered and preserved by the water quality lab, a list of holding times is also provided in Table 1. It is recommended that you submit your water samples to the water quality lab as soon as possible and keep them stored on ice until delivery will help ensure accuracy of the variables measured. The AWRC water quality lab generally completes the analysis of your water sample within two weeks, returning results to clients within three to four weeks.

Table 1: Water quality guidelines for irrigation water and holding times.

Parameter	Level of Concern: Low	Moderate	High	Preservation	Holding Time (Days)
pH	6.5-8.5	<6 or >8.5	<4 or >9	None	2
Electrical Conductivity (µS/cm)	<750	750-3000	>3000	None	28
Alkalinity (As mg/L $CaCO_3$)	<100	100 - 150	>150	None	14
Bicarbonate (As mg/L $CaCO_3$)	<120	120 - 180	>180	None	14
Hardness (As mg/L as $CaCO_3$)	<150	150 - 300	>300	Acidify	180
Fluoride (mg/L)	<1.5	2 - 100	>100	None	28
Chloride (mg/L)	<142	142 - 355	>355	None	28
Sulfate (mg/L)	<300	300 - 400	>400	None	28
Nitrate-N (mg/L)	<5	5 - 30	>30	None	2
Calcium (mg/L)	<124	124 - 150	>150	Acidify	180
Magnesium (mg/L)	<24	24 - 50	>50	Acidify	180
Sodium (mg/L)	<70	70 - 100	>100	Acidify	180
Iron (mg/L)	<0.2	0.2 - 1.5	>1.5	Acidify	180
Manganese (mg/L)	<0.1	0.1 - 1.5	>1.5	Acidify	180
Total Suspended Solids (mg/L)	<50	50 - 100	>100	None	7
Sodium Absorption Ratio (SAR)	<10	10 - 17	>17	Acidify	180
Aggressive Index (AI)	>12	12 - 10	<10	None	2

Below are some general guidelines for determining if the parameters tested in your water sample are acceptable for irrigating your crops.

1 **pH:** The pH of a water sample indicates how acidic (values below 7) or alkaline (values above 7) your water is. The acceptable range for pH is between 6.5 and 8.5 (Table 1); however problems may still occur within this range. Irrigation water with a pH above 8 indicates the presence of bicarbonate, which may cause calcium and magnesium to be lost from the soil. Having pH below 6 can lead to damage to metal components of your water distribution system, and a pH below 4 can contribute to soil acidification. There is no standard method for preservation of samples for pH and should be analyzed within 48 hours of collection for the most accurate results.

2 **Electrical Conductivity (EC):** Electrical conductivity is a measure of how well your water sample conducts electricity, and is related to the salt content or the amount of dissolved ions in the water sample. The maximum acceptable level of conductivity for your irrigation water is 750 microsiemens per centimeter (µS/cm; Table 1). Irrigation water with conductivity greater than 750 µS/cm should be used with caution because irrigating crops with high conductivity water may restrict or inhibit the plants ability to take up water and nutrients. On soils with restricted internal drainage, irrigation water high in EC may lead to salt accumulation, especially in soils where rice is typically grown, which can affect subsequent crops. Crops vary in their sensitivity to increased conductivity, with cotton being more tolerant than rice or soybeans. This variable is naturally stable in most water samples, and collected samples should be analyzed within 28 days.

3 Alkalinity: Alkalinity is a measure of how well water prevents large rapid changes in pH. This is measured in mg/L of calcium carbonate (CaCO3), and the desirable range for sufficient buffering capacity is from 50 – 100 mg/L CaCO3 (Table 1). Well water high in alkalinity can often increase the soil pH to levels that are detrimental to seedling rice especially in paddys closest to the water input at the upper end of the field. Total alkalinity of your water sample should be measured within 14 days of collection.

4 Bicarbonate: Bicarbonate is an important component of total alkalinity, and generally forms as limestone dissolves in the soil. In Arkansas, irrigation water with a pH above 8 is usually due to high bicarbonate and the maximum acceptable concentration in your irrigation water is 120 mg/L as $CaCO_3$(Table 1), water containing more than this should be used with caution. Irrigating crops with water high in bicarbonate can affect the crops roots ability to absorb some nutrients such as iron and zinc. Bicarbonate can also react with calcium forming calcium carbonate leaving less calcium available to combat the effects of sodium (see the sections below on sodium and sodium absorption ratio). For the most reliable estimation of bicarbonate, your water sample should be analyzed within 48 hours of collection.

5 Hardness: Hardness refers to the amount of calcium and magnesium dissolved in the water sample, with iron and manganese also contributing, but to a lesser extent. As hardness relates to alkalinity and the ability to neutralize acid forming compounds it is good for your irrigation water to be slightly hard (75-150 mg/L as $CaCO_3$; Table 1). However, irrigation water measuring >150 mg/L as $CaCO_3$ in hardness will cause a buildup of lime scale in irrigation lines which can decrease flow through lines and clog drip and trickle irrigation systems. Once your sample is processed and preserved in the Lab it is stable for 6 months.

6 Fluoride (F): Fluoride is a trace element found in waters at concentrations ranging from 0.1 to 1.5 mg/L. Fluoride is a common supplement in municipal water sources added to drinking waters for dental health. Concentrations of fluoride in your irrigation water between 0.1 – 1.5 mg/L will not harm crops (Table 1); however, plant injury has been found at levels above 100 mg/L. Fluoride should be analyzed in your water sample within 28 days of collection.

7 Chloride (Cl): Chloride should not be confused with chlorine (Cl_2) which is a highly reactive compound and commonly used as a disinfectant in the water treatment process. Chloride is part of common salt (sodium chloride) and is an essential nutrient required for optimal plant growth. However, high concentrations of Cl (>142 mg/L) can be toxic to plants (Table 1). Certain soybean varieties are very sensitive to elevated chloride levels. Chloride should be analyzed in your water sample within 28 days of collection.

8 Sulfate (SO_4): Like chloride, sulfate is an essential nutrient for crops required for optimal growth, but can also contribute to the overall salinity of your irrigation water. The maximum allowable concentration for sulfate in your irrigation water is 300 mg/L (Breś et al. 2010; Table 1). Sulfate should be analyzed in your water sample within 28 days of collection.

9 Nitrate-Nitrogen (NO_3-N): Nitrate-nitrogen is the concentration of nitrogen in the sample in the form of NO_3. The maximum allowable concentration for NO_3-N in your irrigation water is 30 mg/L (Table 1); however, concentrations greater than 5 mg/L may negatively affect some sensitive crops (sugar beets and grapes). Higher concentrations are beneficial during the early stages of crop growth; however, in later stages of growth can cause over-stimulation, delayed maturity, and/or poor quality. Concentrations greater than 5 mg/L should be taken into consideration when determining fertilizer applications. Nitrate should be analyzed within 48 hours of your irrigation water sample being collected.

10 Calcium (Ca): Calcium is naturally occurring in most water sources and it can come from dissolved rock such as limestone and gypsum. High concentrations of calcium along with magnesium relate to “hard water” which can result in scale formation in your water delivery system, thereby decreasing function. The maximum allowable calcium concentration for your irrigation water is 150 mg/L (Table 1). Once your water sample is processed and preserved in the laboratory it is stable for 6 months.

11 **Magnesium (Mg):** Similar to calcium, magnesium is naturally occurring in most water sources and comes from dissolved rock such as dolomite. Magnesium also relates to "hard water" which can result in scale formation in water delivery systems. Concentrations less than 50 mg/L are safe for irrigation water for most crops (Table 1). Once your sample is processed and preserved in the laboratory it is stable for 6 months.

12 **Sodium (Na):** Usually found in association with chloride, sodium occurs in water from the dissolving of rock and salts. In high concentrations sodium can be toxic to crops and influence their ability to take up nutrients from the soil. High sodium concentrations in your irrigation water can also negatively influence your soil resulting in poor soil structure that causes reduced water infiltration. To prevent toxicity to crops and issues with soils sodium concentrations should be less than 70 mg/L (Table 1). Once your sample is processed and preserved in the laboratory it is stable for 6 months.

13 **Sodium Absorption Ratio (SAR):** This parameter is a unit less proportion of sodium to calcium and magnesium in your water sample, all measured in milliequivalents per liter (meq/L) as seen in the equation below. Discussion of what meq/L is and how to convert variables between it and mg/L can be found in the next section. Water containing a high concentration of sodium in relation to calcium and magnesium is defined by a SAR values > 17 (Table 1). When your irrigation water has a high SAR value, sodium in the water replaces calcium and magnesium in the soil and this in turn decreases the permeability of the soil (Miller and Gardiner 2007). Once your sample is processed and preserved in the laboratory it is stable for 6 months.

$$SAR = \frac{Na}{\sqrt{(0.5*(Ca+Mg))}}$$

14 **Iron (Fe):** The water sample is analyzed for concentrations of total dissolved iron and will not distinguish between unoxidized (ferrous) and oxidized (ferric) forms. Iron concentrations less than 5 mg/L are not toxic to crops; however, concentrations as low as 3 mg/L can result in drip and trickle irrigation systems becoming clogged (Table 1). Once the water sample is processed and preserved by the laboratory, the holding time for analysis is 6 months.

15 **Manganese (Mn):** Manganese will generally occur in lower concentrations than iron. Manganese concentrations less than 0.5 mg/L are suitable for most crops and concentrations greater than 1.5 mg/L will clog irrigation equipment (Table 1). Once the water sample is processed and preserved by the laboratory, the holding time for analysis is 6 months.

16 **Total Suspended Solids (TSS):** This is a measure of all the suspended solids in your irrigation water which includes silt and clay particles and other organic particles. There is not a lot of concern over TSS for standard irrigation systems; however in drip and trickle irrigation systems TSS should not be more than 50 mg/L (Table 1). Additionally, a filtration system should be set up to remove all particles in your water that are greater than 1/10 of the size of the smallest emitter diameter (Rogers et al. 2003). Water samples should be analyzed for TSS within 7 days of collection.

17 **Aggressive Index (AI):** This is an indication of how corrosive your water is. It is calculated from the pH, hardness and alkalinity from your water sample and like SAR is a unit less parameter. This parameter is ranked opposite of what one might think. Water with a high AI value (values greater than 12) is not corrosive; while irrigation water with a lower AI values (< 10; Table 1) are corrosive and may dissolve metal components of your irrigation system leaching metals such as iron into your irrigation water. There is no standard method for preservation of samples for pH and should be analyzed within 48 hours of collection for the most accurate results.

Conversion Of Commonly Used Units

The units for all of the ions reported in your analytical report provided by the AWRC Water Quality Lab will be in the form of milligrams per liter (mg/L). However, other analytical labs may provide ion data reported in milliequivalents per liter (meq/L). Additionally, certain parameters require the variables they are calculated from to be in the form of meq/L, as in the case of SAR. So what is meq/L and how does it differ from mg/L? Milligrams per liter is a concentration based on the mass of a substance dissolved in a volume of water; whereas, meq/L is a numerical expression of the concentration of a salt, based on the atomic weight of a substance divided by its valence (Bauder et al. 2008). Essentially, meq/L is used to compare concentrations of ions with different atomic weights and charges. If you need to convert the mg/L values found in your analytical report to meq/L or vice versa Table 2 provides conversions for the salts listed in this fact sheet.

Convert 4 meq/L of Chloride to mg/L
= 4 x 35 = 140 mg/L Cl

Table 2: Conversion factors for converting parameters from mg/L to meq/L and from meq/L to mg/L.

Parameter	Convert mg/L to meq/L multiply by	Convert meq/L to mg/L multiply by
Sodium (Na)	0.043	23
Calcium (Ca)	0.050	20
Magnesium (Mg)	0.083	12
Chloride (Cl)	0.029	35
Sulfate (SO_4)	0.021	48

Summary

Having a reliable water source with good water quality is integral for irrigation. Testing water resources regularly can help ensure that you are providing suitable water for crop production. This fact sheet is intended to provide information on acceptable concentrations of various elements and compounds for both irrigation analytical packages. If the water is being used for additional purposes, such as livestock or poultr y production, it is important to take into consideration the recommended concentrations for these other intended purposes when managing your water resources. If you have specific questions regarding how your water quality may influence your crops please contact Dr. Mike Daniels, Dr. Leo Espinoza, or Dr. Chris Henry, with the University Of Arkansas Cooperative Extension Service (mdaniels@uaex.edu, lespinoza@uaex.edu, or cghenry@uark.edu.).

Literature Cited

Bauder, J.W., T.A. Bauder, R.M. Waskom, and T.F. Scherer. 2008. Assessing the suitability of water (Quality) for irrigation – salinity and sodium.

Breś W., T. Kleiber, T. Trelka. 2010. Quality of water used for drip irrigation and fertigation of horticultural plants. Folia Horticulturae Ann. 22(2): 67-74.

Bucks, D.A., F.S. Nakayama, and R.G. Gilbert. 1979. Trickle irrigation water quality and preventative maintenance. Agricultural Water Management. 2: 149-162.

Miller, R.W., and D.T. Gardiner. 2007. Soils in our environment. 9th ed. Prentice Hall-Inc., Upper Saddle River, New Jersey 07458. ISBN 0-13-020036-0, page 452.

Lamont, W.J. Jr., M.D. Orzolek, J.K. Harper, L.F. Kime, and A.R. Jarrett. 2002. Drip irrigation for vegetable production. Pennsylvania State University Extension. Fact Sheet UA370.

Rogers, D.H., F.R. Lamm, M. Alam. 2003. Subsurface drip irrigation systems (SDI) water quality assessment guidelines. Kansas State University. Fact Sheet MF-2575

How To Cite This Fact Sheet

Austin, B.J., L. Espinoza, C. Henry, M. Daniels, and B.E. Haggard. 2016. How to Collect Your Water Sample and Interpret the Results for the Irrigation Analytical Packages. Arkansas Water Resources Center, Fayetteville, AR, FS-2017-03: 08pp

ARKANSAS WATER RESOURCES CENTER

UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

UNIVERSITY OF ARKANSAS

Arkansas Water Resources Center
479.575.4430
awrc@uark.edu
College of Engineering
203 Engineering Hall
University of Arkansas
Fayetteville, AR 72701